CHEMICAL & PROCESS ENGINEERING

A monthly international review of chemical plant and operations for all industries

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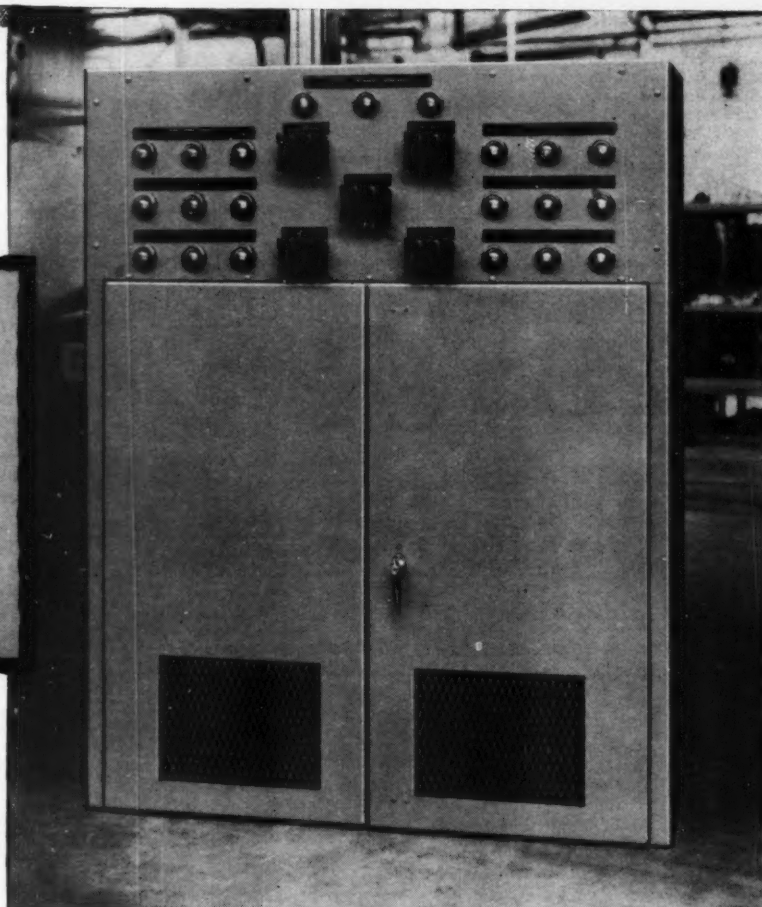

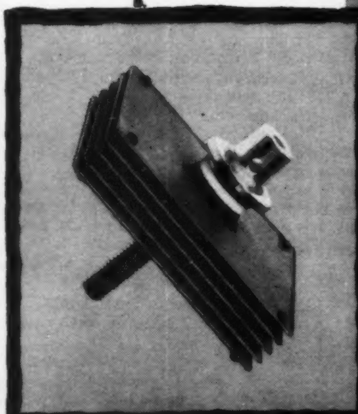

HEWITTIC GERMANIUM AND SILICON RECTIFIERS

THE above illustration shows one of a number of Hewittic germanium rectifiers employing Hewittic germanium rectifier diodes. A close up view of one of these diodes is shown alongside.

For Germanium and Silicon rectifiers specify Hewittic—the name backed by over 50 years rectifier manufacturing experience.

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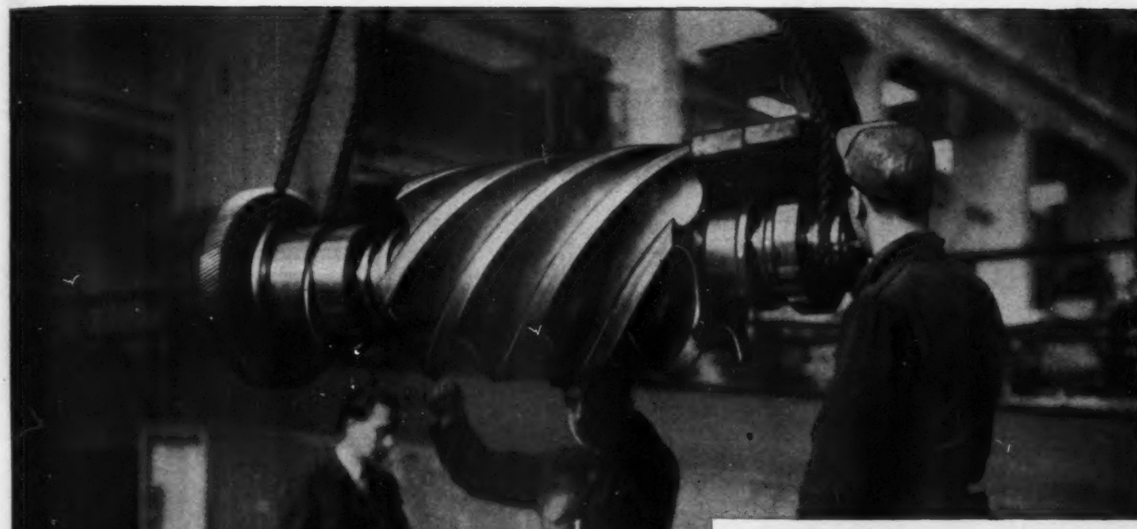
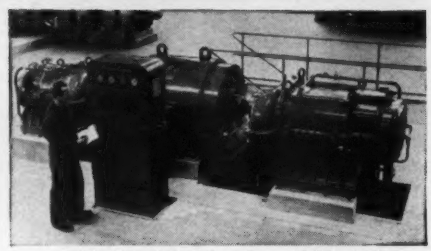
A New Rotary Screw Compressor

THE ATLAS COPCO

TWIN-AIR



Fitting the female rotor in a Twin-Air compressor.



An Atlas Copco 'Twin-Air' compressor (8,100 c.f.m.) at the Grängesberg mine, central Sweden.

NO METALLIC CONTACT BETWEEN COMPRESSION COMPONENTS—this means *no wear*... long intervals between overhauls... minimum maintenance.

HIGH EFFICIENCY—cuts power waste—and operating costs.

SPACE SAVING—simple, compact design effects marked reduction in installation costs.

SMOOTH AIR FLOW—no 'surging' or 'pumping' characteristics.

OIL-FREE AIR OR GAS—no lubricant is present in the compression chamber.

LESS SENSITIVE TO IMPURE AIR—because compression components are not in metallic contact.

BASED ON A SWEDISH INVENTION

Atlas Copco Twin-Air compressors—based on the original design of the Swedish Inventor, Lysholm—have already been fully tested at Kiruna in the Arctic Circle area of Northern Sweden. Here, at the world's largest underground iron mine, they have been operating under normal working conditions for two years.

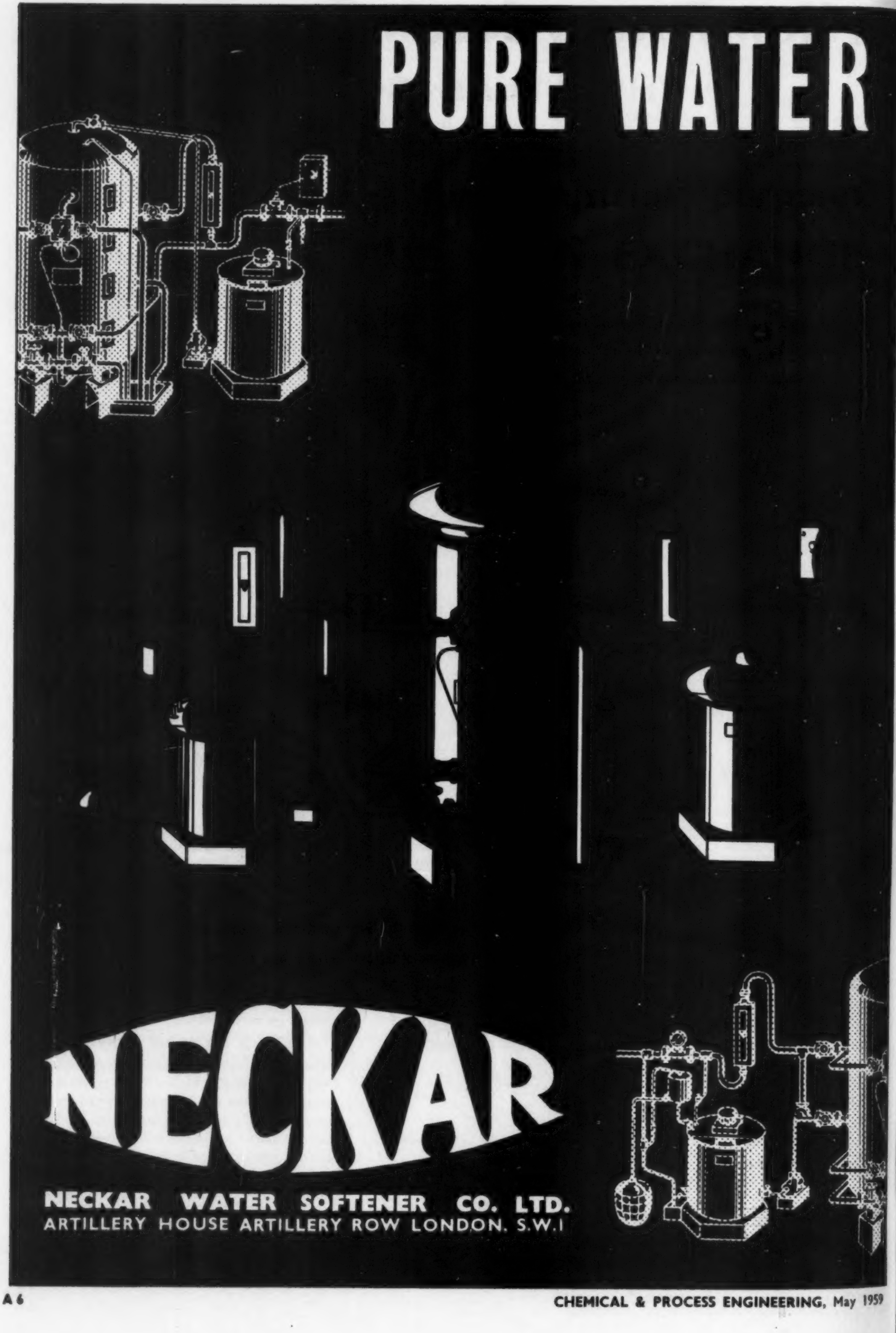
NOW A TWIN-AIR PORTABLE!

Atlas Copco introduces the *world's first* PORTABLE Rotary Screw Compressors! These portable machines embody all the know-how gained from two years operating experience with Twin-Air Stationary Compressors. The first models in this new range are machines of 370 c.f.m. and 620 c.f.m. Both 100% air-cooled, diesel-powered units.

Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

For details of the new Atlas Copco Rotary Screw Compressors, contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden, or Atlas Copco (Great Britain) Limited, Beresford Avenue, Wembley, Middlesex

C.36/8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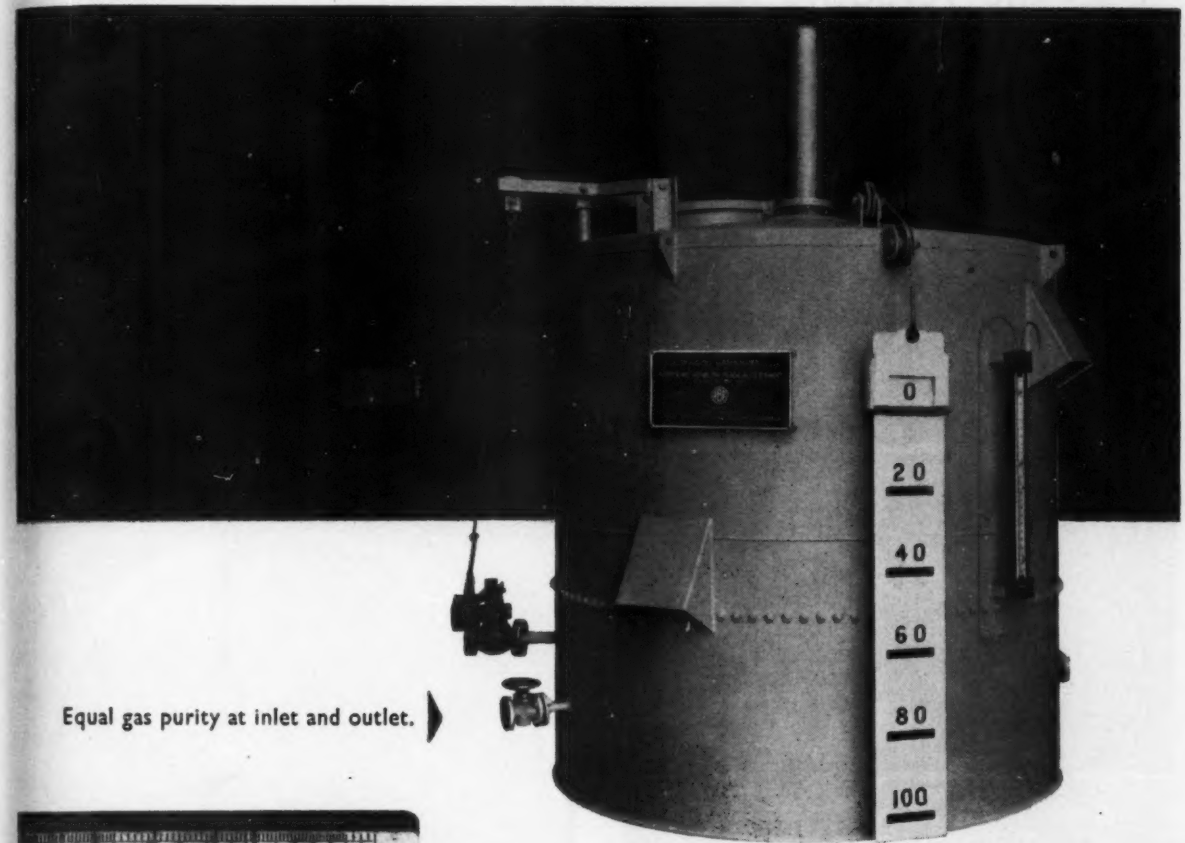
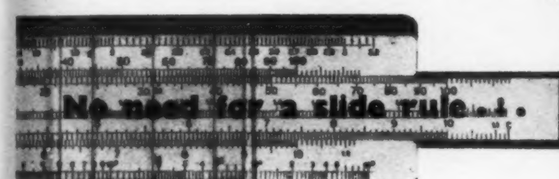


Equal gas purity at inlet and outlet.



will solve these 'equations' for you

(I)	$\frac{\text{Pure Gas}}{H_2O}$	+ atmospheric pollution = $\frac{\text{Pure gas}}{\text{Contaminated } H_2O}$ = Impure gas, at outlet.
(II)	$\frac{\text{Acidic gases}}{H_2O}$	= Corrosion + leakage.

Capacity range of Wiggins gasholders—50 cu. ft. to 5,000,000 cu. ft.

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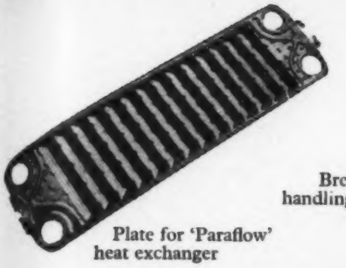
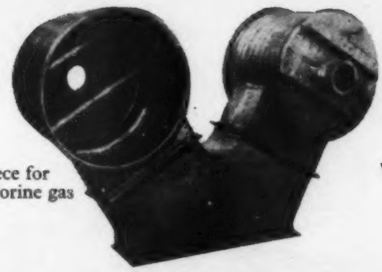
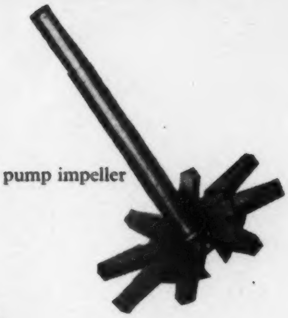


Plate for 'Paraflow' heat exchanger



Breeches piece for handling wet chlorine gas



Welded pump impeller

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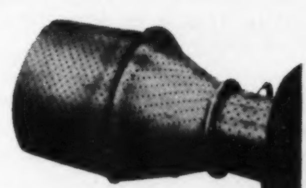
More and more, chemical engineers are turning to I.C.I. Titanium as the solution to some of their most harassing corrosion problems. The phenomenal resistance of titanium and its alloys in aggressive environments has opened the door to cheaper and purer chemical production, new techniques and processes. Why not enquire *now* whether I.C.I. Titanium can help you?

Titanium-lined steel reactor vessel

Photos. by courtesy of: A.P.V. Co. Ltd. J. R. Bramah & Co. Ltd. Ilford Ltd. and H. Braithwaite & Co. Ltd. Marston Excelsior Ltd.

Condenser

Photographic emulsion pan, titanium lined



Automatic pickle drum

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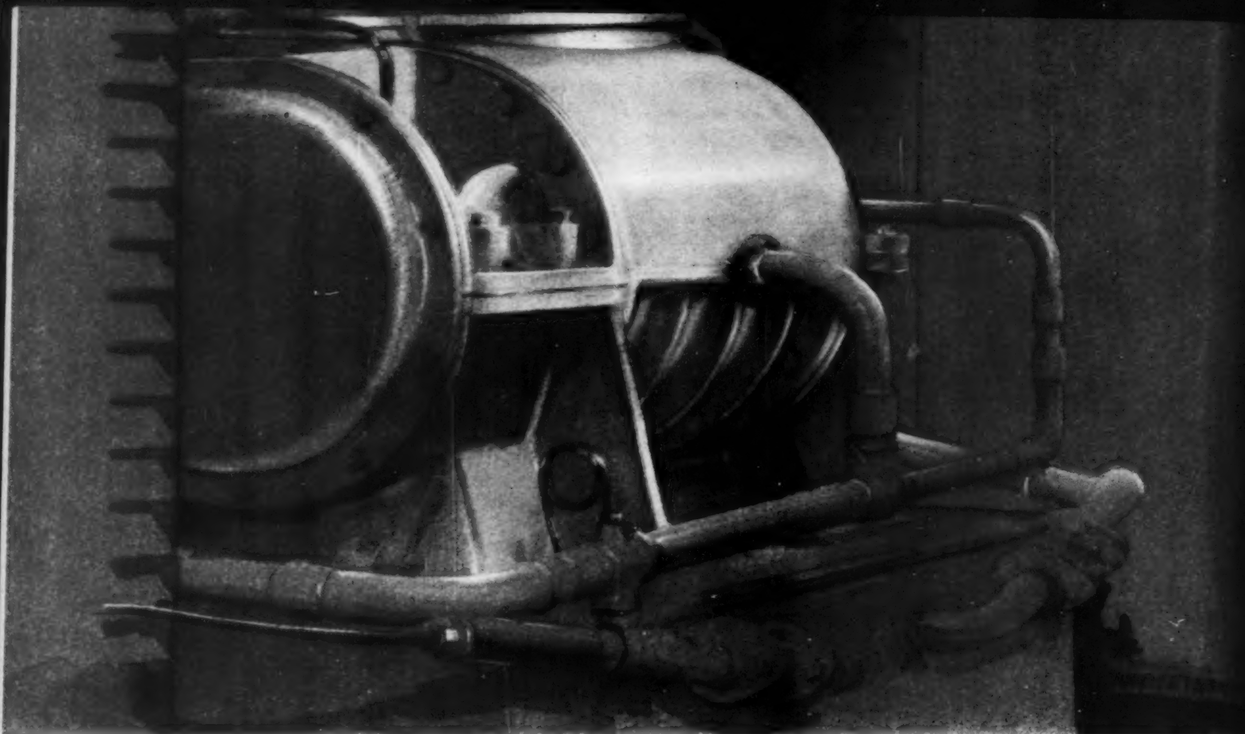
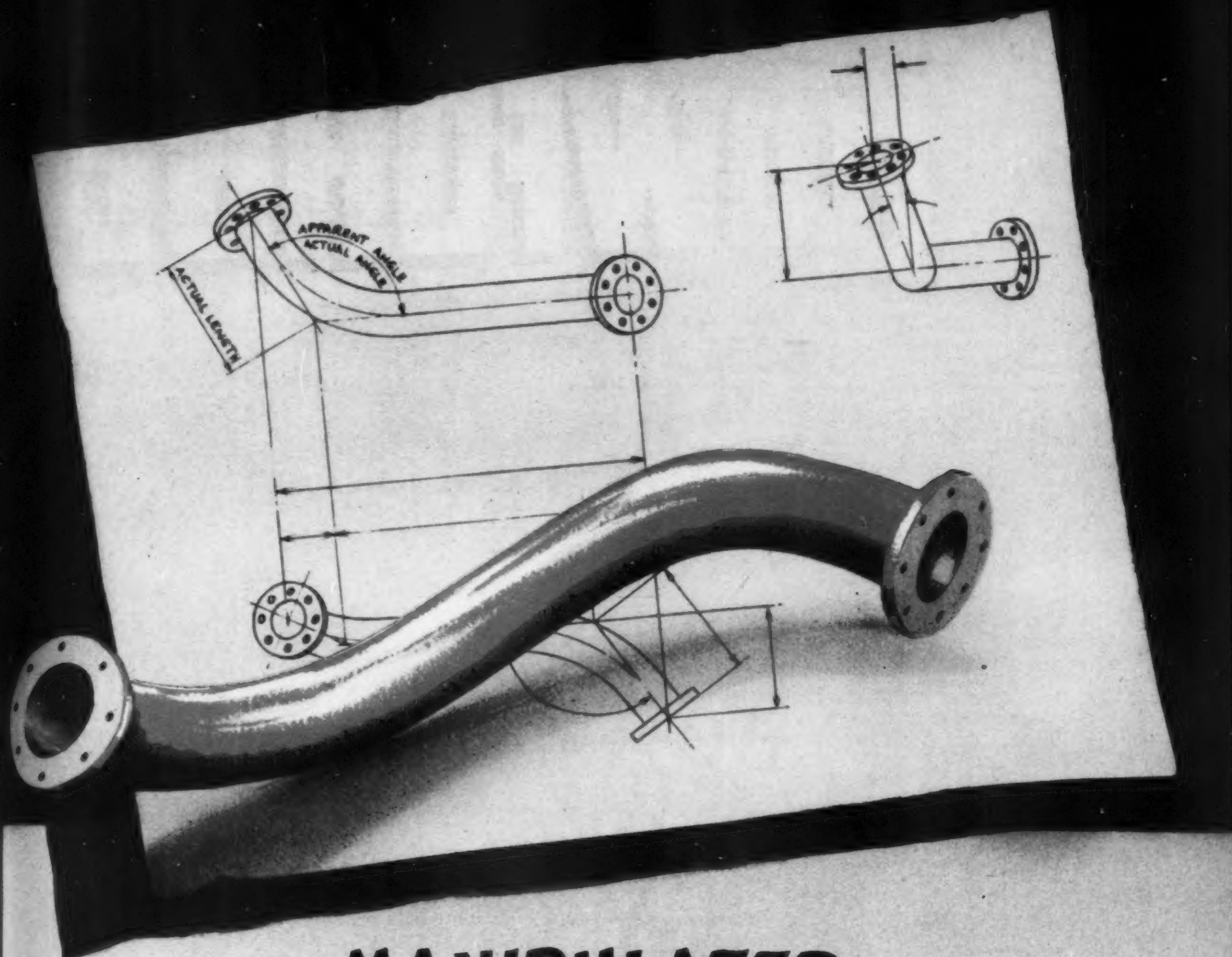
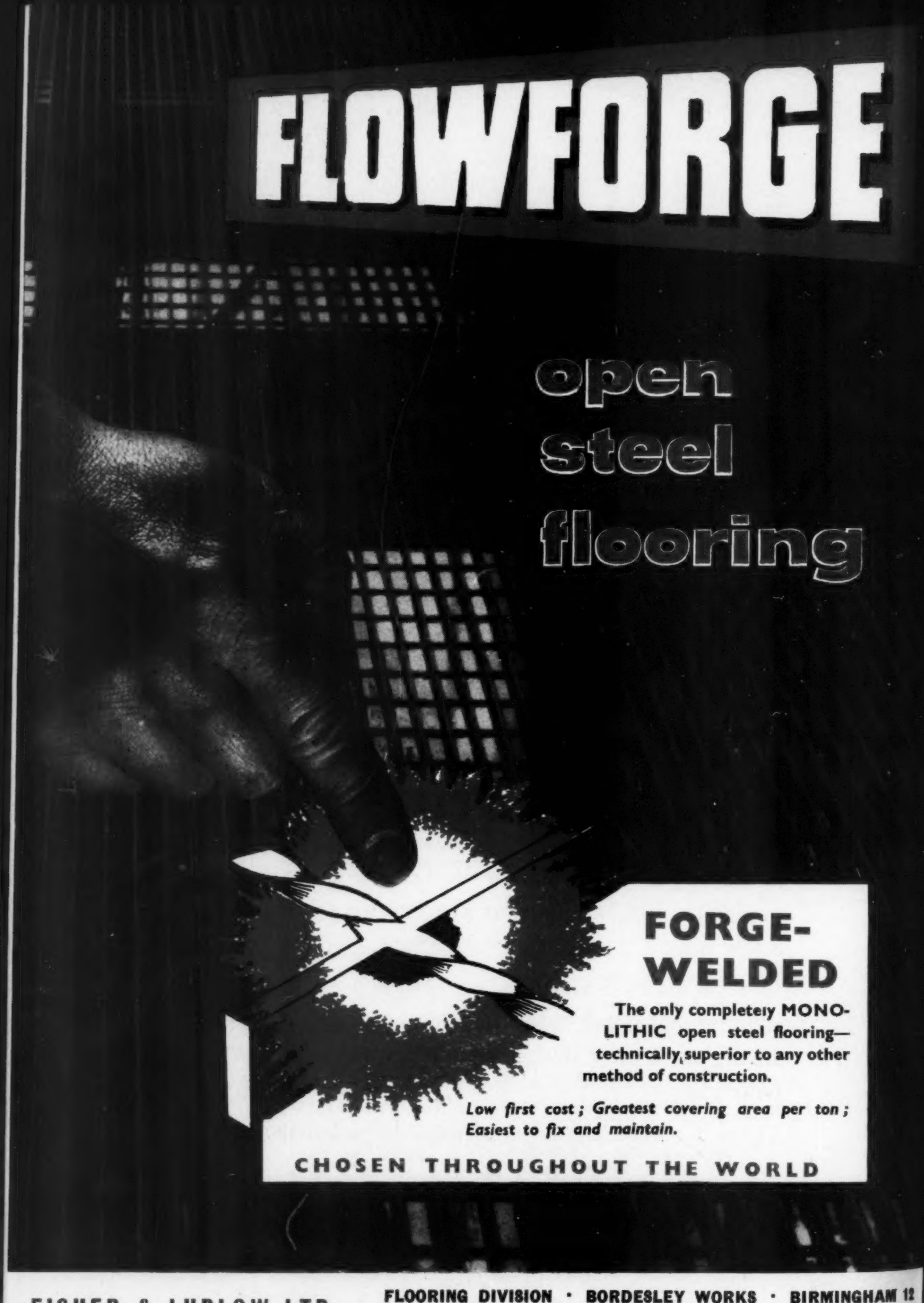
TM 30



Howden compressor at the National Gas Turbine Establishment, Farnborough: (Crown Copyright reserved)
Delivery—air at 5500 c.f.m. against 30 p.s.i.g.


APPARENT ANGLE
ACTUAL ANGLE
ACTUAL LENGTH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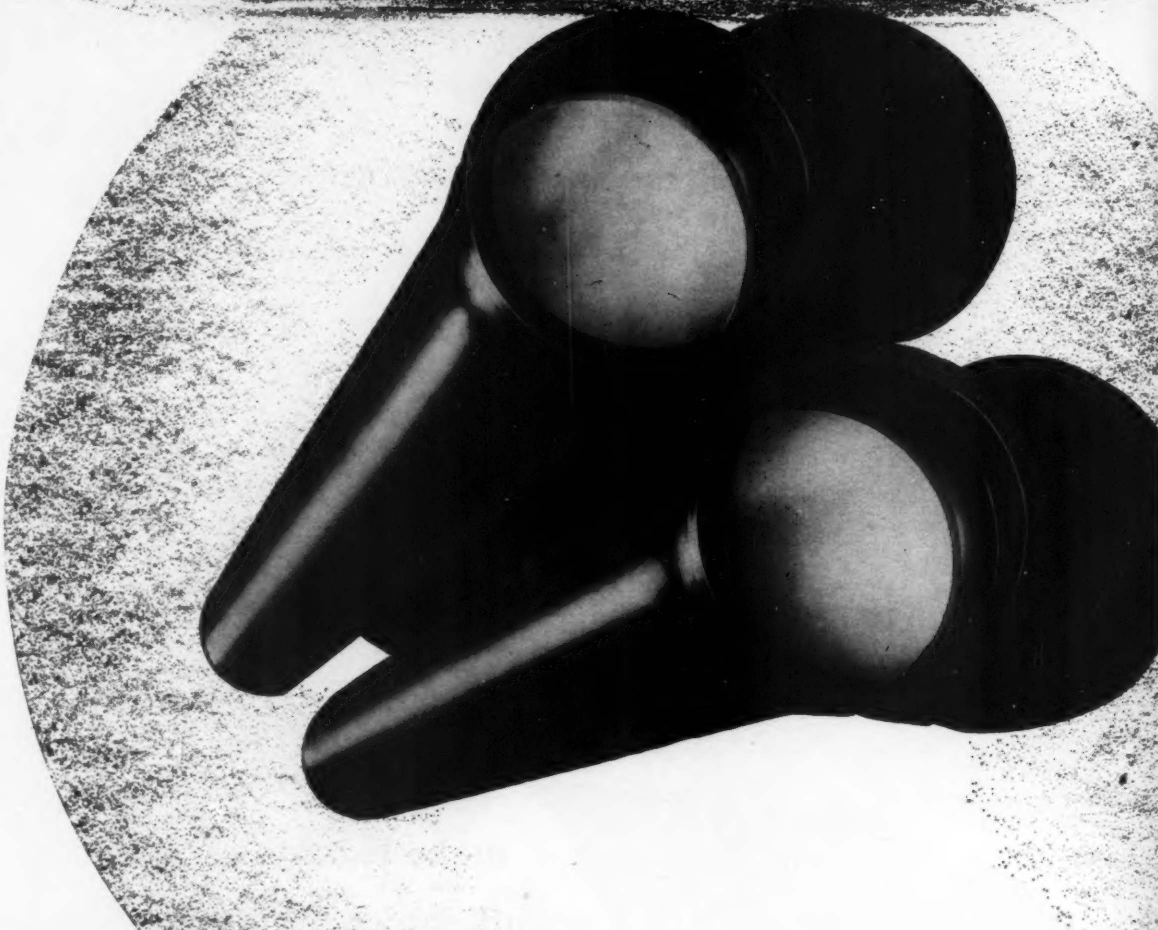

158 ton fusion welded tower for Fawley

Shown below, in transit to the Esso Refinery, Fawley, is a 105-ton section of a 158-ton, 137 ft.-high stabilising tower fabricated by BABCOCK fusion-welding, to the order of the Lummus Co. Ltd., for Esso Petroleum Co. Ltd.

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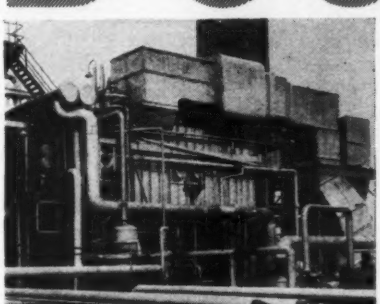
Babcock & Wilcox Ltd. is outstandingly well equipped in experience, techniques and manufacturing facilities to meet the demands of the oil and chemical industries for complete steam-raising plants, pressure vessels (in mild-steel or clad plate), separately-fired superheaters, heat exchangers and waste-heat utilization plant.

Many of the world's largest pressure-vessels have been Babcock fusion-welded, including the giant heat-exchangers of Britain's first atomic power stations and a large number of treating towers for the world's oil refineries and chemical plants. The Company has, indeed, an exceptional experience of fabrication by fusion-welding and as the world's largest maker of steam-raising plant, has a thorough understanding of the principles and problems of heat-exchange.



BABCOCK plant at Fawley includes oil and gas fired boiler plant. Above: one of the outdoor type FH Integral Furnace boilers.

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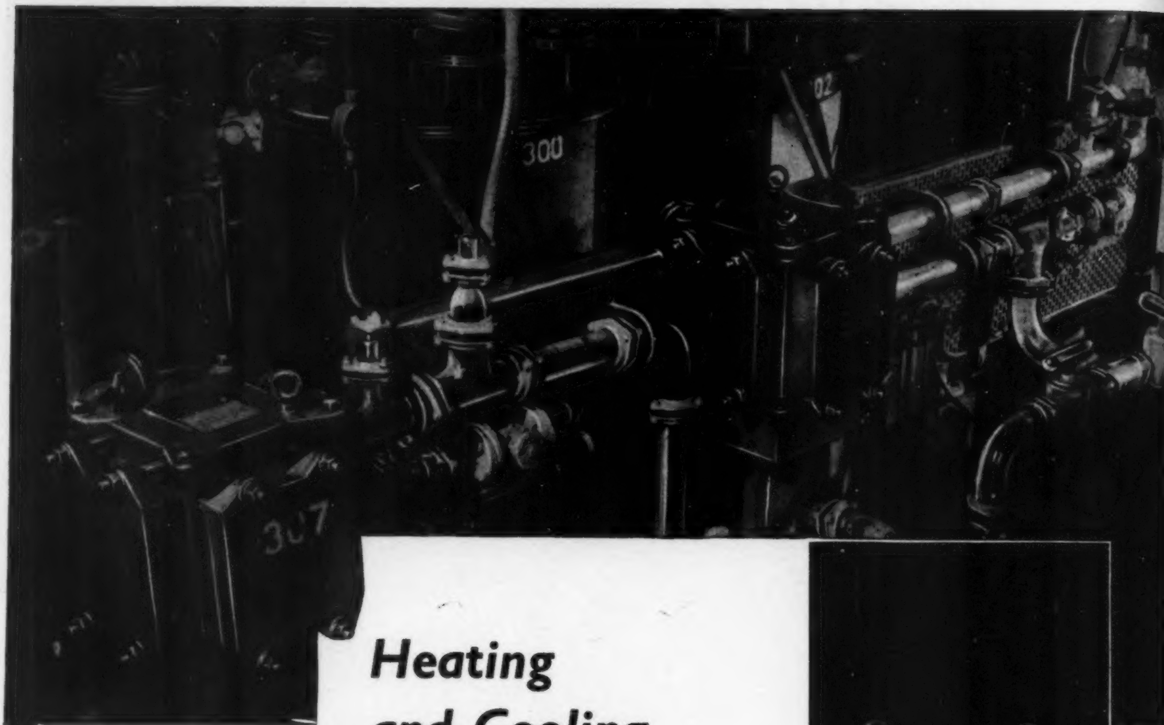
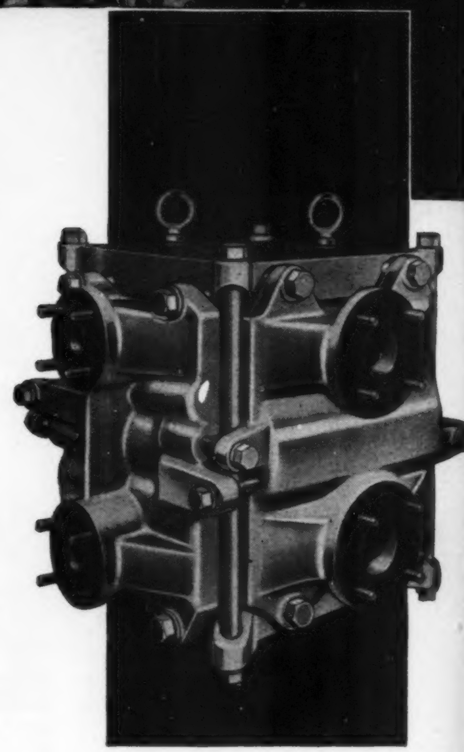
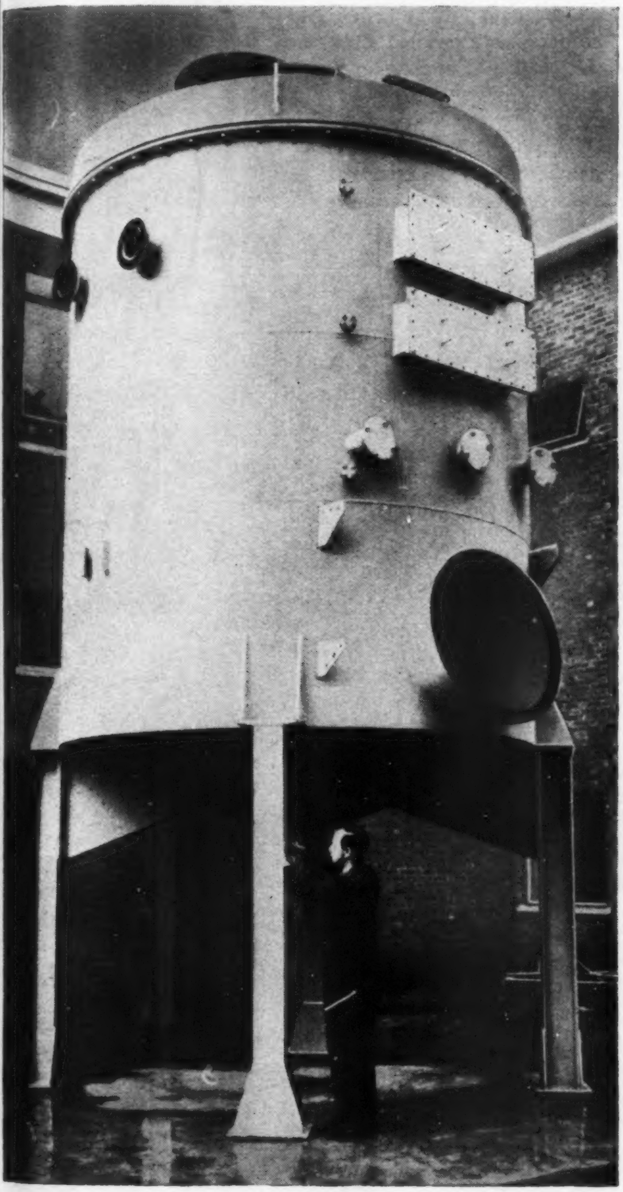




LINED TO LAST – NO 2

CLEAN AIR



through Silvertown rubber linings

The fight against atmospheric pollution by industrial processes is advanced by the use of gas scrubbers—but the elimination of contaminants such as combustion exhaust, process gases and finely divided residues is invariably accompanied by the corrosion of exposed metal surfaces.

For complete protection of plant liable to corrosive influences enlist the aid of Silvertown Rubber. Peabody Ltd chose a Silvertown Lining for the giant scrubber illustrated—and with good reason, for years of development and experience were readily available to tackle the problem.

If *you* have a corrosion problem let Silvertown materials and methods solve it.

Peabody Scrubber supplied for a Keith Blackman Ltd extraction system installed at Raleigh Industries Ltd handling the exhaust gases from cyanide hardening furnaces.

Silvertown

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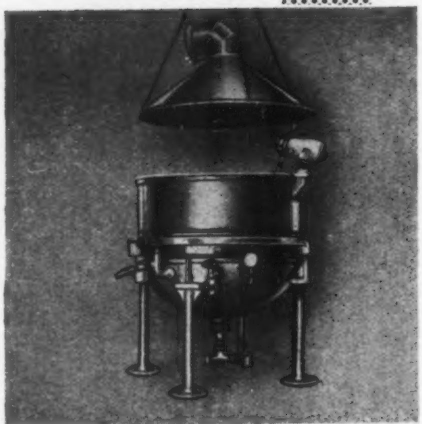

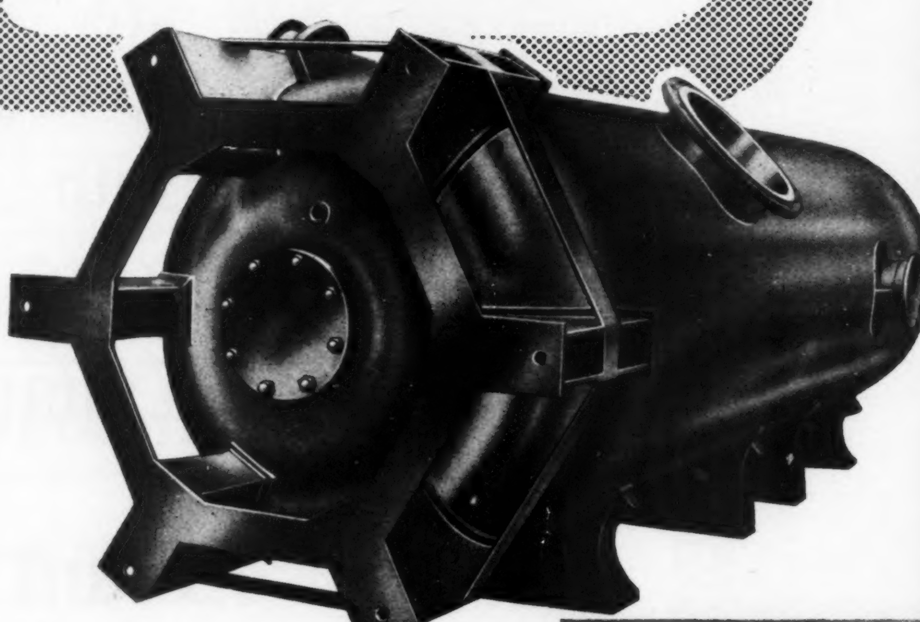

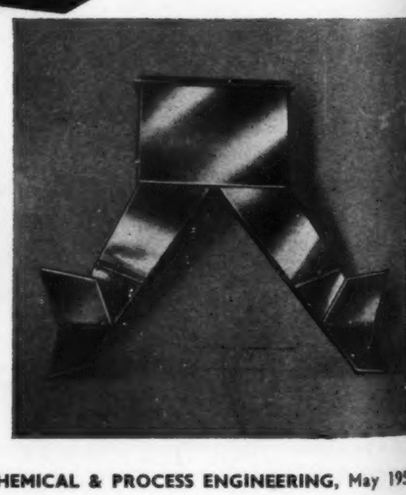

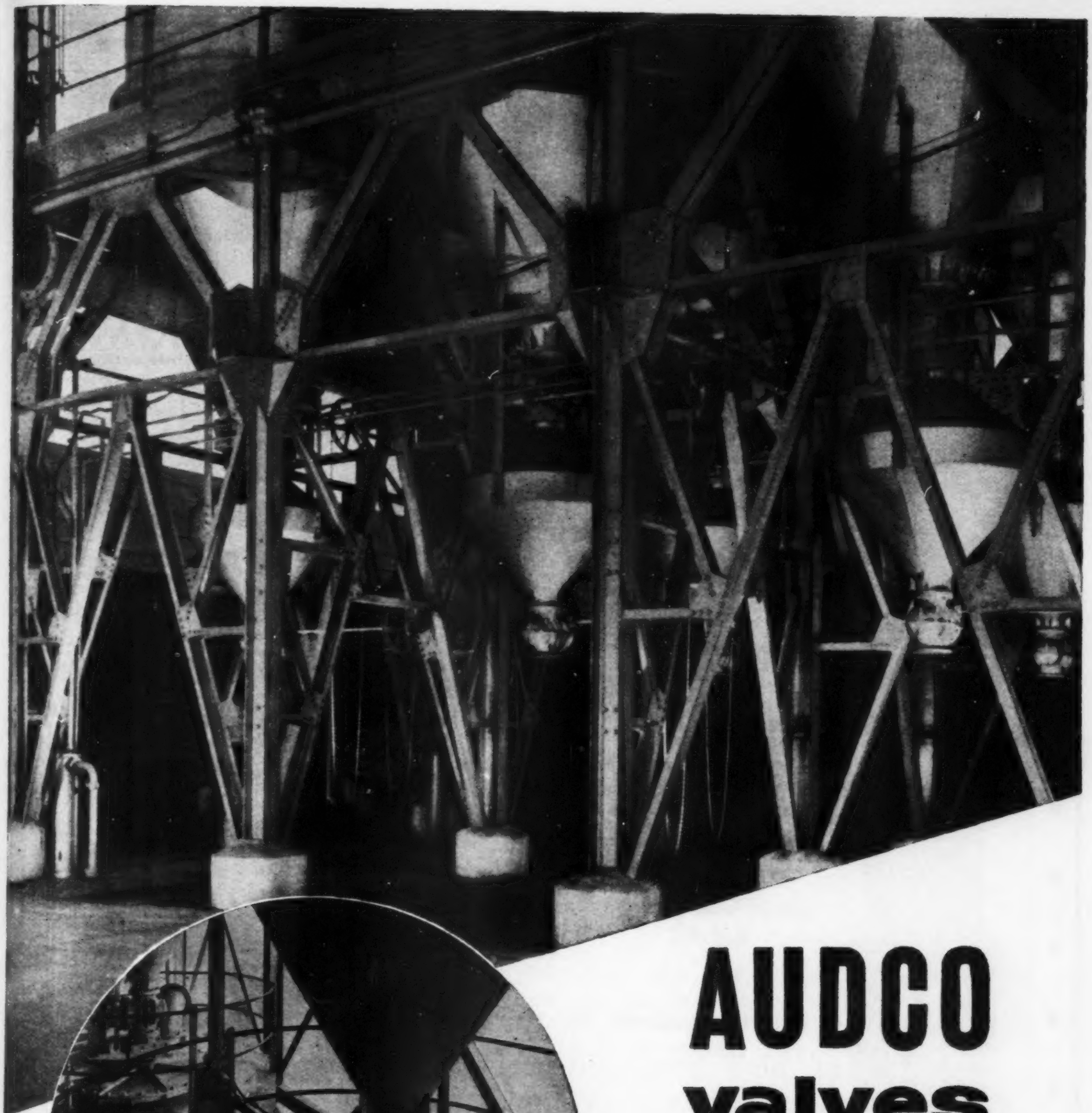

The illustration shows Audco valves installed on Gastechnik purifiers, Bankside Works, Hull (courtesy of the North-Eastern Gas Board)

AUDCO valves

LUBRICANT SEALED FOR A POSITIVE SHUT-OFF

Cut your maintenance costs by installing Audco lubricated plug valves . . . they cost no more than ordinary valves and cost less to maintain.

A unique pressurised lubricant system provides a leakproof seal and ensures easy rotation of the plug (without friction) under extremes of temperature and pressure . . . other economy features include taper seats which are not exposed to moving fluids, quarter turn operation and a rotary plug which is the *only* basic moving part.

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AUDCO VALVES

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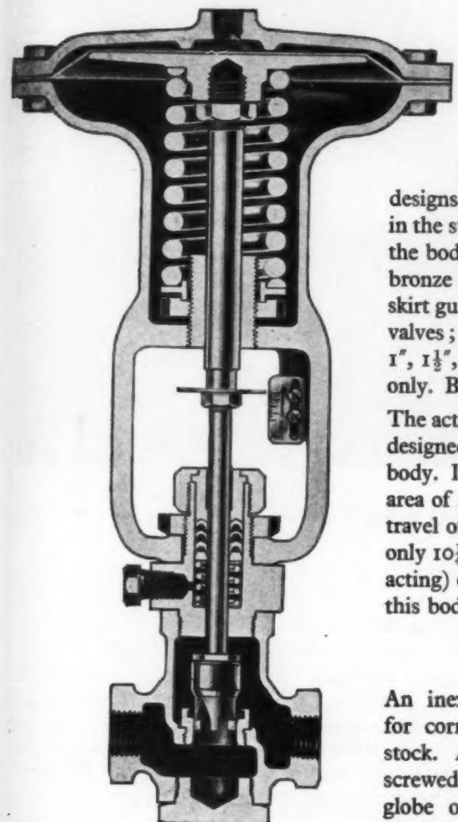
Diaphragm Control Valves

NEW BODY RANGES



Style "G" The new body design "G" provides an economical valve for handling low pressure steam, gases or liquids where more expensive designs of body are not warranted. It is provided with Teflon V-ring packing in the stuffing box and the bonnet and bottom cap are attached to the body with a screwed joint. The body can be supplied in bronze or stainless steel, and is available with Micro-Flute, skirt guided Quick Opening, or skirt guided V-Port inner valves; trim material is Type 18/8 stainless steel. Sizes 1", $1\frac{1}{2}$", and 2" made with screwed ends only. Body is rated 150 psig at 366°F.

The actuator Type 510 (illustrated) is designed primarily for the Type G body. It has an effective diaphragm area of 25 sq. in. and a maximum travel of $\frac{3}{4}$". Overall measurement is only $10\frac{1}{4}$". Actuator Types 511 (reverse acting) or 655 may also be mounted on this body.

Style "B"

An inexpensive Heavy Duty valve body for corrosive liquids, machined from bar stock. Available in $\frac{1}{2}$", $\frac{3}{4}$" and 1" sizes with screwed or socket welding ends in either globe or angle construction and can be machined from stainless steel, carbon steel, Monel or Hastelloy. Body is rated 1500 psig at 450°F.

Type 510 or 511 diaphragm actuators are used with these bodies to provide a compact reliable control valve.

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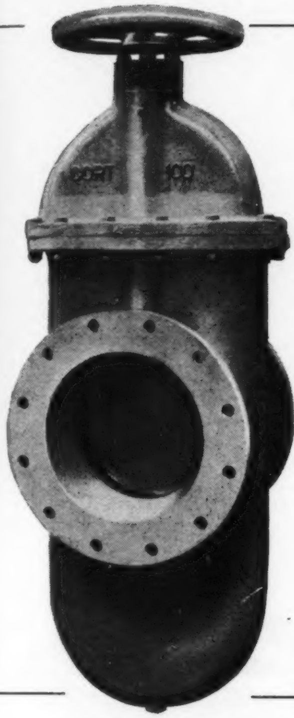


CORT "100" VALVE

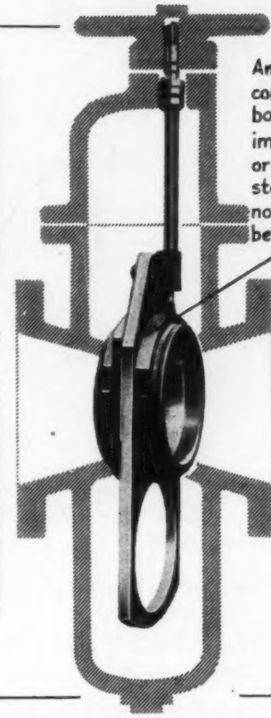
VENTURI TYPE

INTERNAL SCREW

CORT "250" VALVE

FULL BORE

EXTERNAL SCREW



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CORT "250" · 250 lbs. per sq. in. } Chemicals, Etc.

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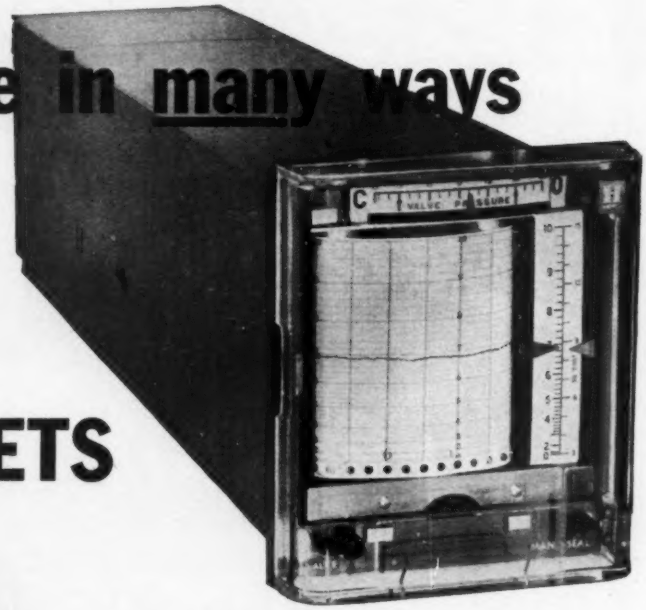

Quick connect Tel-O-Set controller, for proportional control—with automatic reset—of any variable. Derivative action is easily added.

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- Startup is safeguarded by wiring and piping case separately . . . keep chassis safe in original carton until startup.
- Quick-connect design makes chassis mounting easy, fast, foolproof.

CUT SPARE PARTS INVENTORY

- Change recorder to indicator and vice versa . . . without changing case or disturbing field connections.
- One basic controller model for any variable—derivative action easily added.

REDUCE PROCESS DOWNTIME

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- Zero and span, the only recorder adjustments required, are set from front of panel.
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SAVE IN MAINTENANCE

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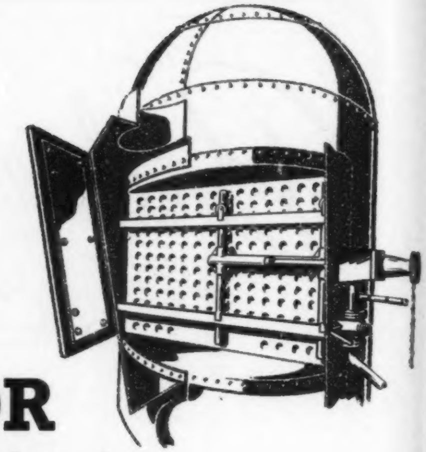

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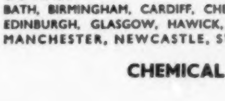

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Chemical & Process Engineering

Vol. 40, No. 5 — MAY 1959

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TOPICS OF THE MONTH

'Hidden men' still hiding

NUMEROUS authorities, including this journal, have acknowledged the fact that chemical engineering in recent times has emerged as the fourth primary technology—as one of the major branches of engineering knowledge which, along with civil engineering, mechanical engineering and electrical engineering, is vitally important in reshaping the industrial face of this world we live in.

And we know it is. We have seen the amazing changes that it has wrought in chemical manufacture, in oil refining, in food processing, ore dressing, the manufacture of paper, pulp, paint and plastics, and, indeed, in every major industry and countless minor ones. Without chemical engineering, atomic energy could not have been made the practical reality that it is today. A tremendous challenge still awaits chemical engineering in helping the world to make the utmost use of its raw materials, to feed its undernourished millions.

So we would confidently expect that in every highly industrialised country the profession of chemical engineering would be a highly revered one, and that its high status would be reflected in its numerical strength.

In Britain, unfortunately, there are no precise, reliable figures to show just how many chemical engineers there actually are, and how they compare in strength with civil, mechanical and electrical engineers. But we can get some idea from the total membership of the main professional institutions concerned. Here they are:

Institution of Mechanical Engineers	50,147
Institution of Electrical Engineers -	44,556
Institution of Civil Engineers - -	24,070
Institution of Chemical Engineers -	4,281

The figures in each case are the latest available totals for all grades of members. Of course, it should be taken into account that the Institution of Chemical Engineers, founded in 1922, is only a youngster compared with the other three institutions, which have been going since 1818 (Civil Engineers), 1847 (Mechanical) and 1871 (Electrical), respectively. Also, there are bound to be certain differences in the academical standards laid down for admission. All the same, on this showing no one looking at these figures impartially would suspect that chemical engineering is the vital new force that it is.

The I.Chem.E. itself is well aware of this situation. In its annual report, published at its annual general meeting on April 28, the Council considers that, while the rate of growth of the Institution is high, 'the total membership is not compatible with the status of one of the major engineering institutions in the United Kingdom.' It goes on to review the steps it has taken to find out the pattern of supply and distribution of chemical engineers in Britain—the results of its survey were commented on in CHEMICAL & PROCESS ENGINEERING, 1958, **39** (11), 381. The Institution has now initiated pilot surveys to estimate to what extent chemical engineers employed in industry do not belong to the Institution. Herein, we feel, lies the key to the assessment of Britain's real chemical engineering strength, and the results of these enquiries should be interesting to see.

Whilst saluting the Institution for its splendid efforts on behalf of the profession, we are not so much concerned with how this excellent body is going to increase its membership as with the implications that its findings have for the healthy state of chemical engineering in industry, and therefore for the technological future of the country. There can be no doubt that there are a great many chemical engineers who do not belong to the Institution. Undoubtedly, too, there are quite a lot of people in industry, primarily either chemists or engineers, who perform the functions of a chemical engineer without having had any recognised course of training in the subject or without even knowing, exactly, what is meant by 'chemical engineering' (the professional institutions in various countries have their own definitions of 'chemical engineering' or 'process engineering' but various other authorities in industry or teaching have put different interpretations on the subject so it is not surprising to find a little confusion amongst practising chemical engineers themselves). These are the 'hidden men' of the process industries referred to in Ross and Freshwater's 'Chemical Engineering Data Book.'*

All this seems to indicate that there are many more chemical engineers than the published figures show. As industry is still calling for more of them it seems that it would be a profitable line of research to find out how many chemical engineers are being wasted in some occupation more suitable for a chemist or mechanical engineer, and how many personnel regarded as chemists or mechanical engineers are, in effect, chemical engineers or near-chemical engineers. If industry can itself review its current needs and available resources of chemical engineering manpower in this way, it might be found that it is not entirely a question of waiting until the universities and colleges are in a position to turn out the required numbers of impeccably qualified chemical engineers.

New light on heavy chemicals

HOW heavy is a chemical? The term 'heavy chemicals' used to be applied almost exclusively to inorganic substances, such as sulphuric acid or alkali, produced in large quantities to sometimes not very exacting standards of purity. But in these days

* *Chemical Engineering Data Book*, by T. K. Ross and D. C. Freshwater, Leonard Hill [Books] Ltd., Eden Street, London, N.W.1, 1958. Pp. 1,200, illus., 84s. net.

there are quite a lot of organic chemicals required in very big quantities, so they must be called 'heavy' too. Moreover, many heavy chemicals have today to be made to standards of purity comparable with those of the so-called 'fine' chemicals.

Attention is drawn to this interesting situation in the latest annual review of Imperial Chemical Industries Ltd., who were so tickled with the idea that, as mentioned in a previous issue of CHEMICAL & PROCESS ENGINEERING, they went and set up a Heavy Organic Chemicals Division. The review says that the new division has been doing very well for itself, so there must be something in it. Packaging note: the division has gone in for bulk delivery of liquid products in a big way, using road, rail and sea tankers, and the idea seems to have paid off, especially in the export trade. Storage depots for supplying customers have been established at strategic points on the Continent.

In the alkali trade, total sales were lower than in 1957. At home, it is not surprising to find that the recession in the rayon industry affected sales of caustic soda; abroad, they continued to meet severe competition, as happens with many other products of the chemical industry. But under the circumstances I.C.I.'s export total of £73.8 million for all products compares very favourably with the £72.5 million of 1957.

In its annual report, I.C.I. notes the emergence of a factor not experienced for many years, namely, the operation of a number of plants at levels appreciably below their full capacity, as the principle cause of the increase in the group's costs during 1958. A further factor contributing to higher costs was the initial expenditure incurred in establishing production on new plants. However, there was a brighter side, for although there were further increases in wages and salaries, these were on a reduced scale, while some raw materials were obtained at reduced prices. Expenditure in 1958 on the company's programme of construction in the U.K. was £45.3 million compared with £50.6 million in 1957. New projects include the extension and modernisation of plant for the production of light soda ash at the Alkali Division's Lostock works; a new calcium carbide plant; further development of the rock salt mine at Winsford; extension of the methanol plant at Heysham; a new nitric acid plant at Ardeer; and a further stage in the development of the site and services at Wilton works.

Fresh moves on carbide manufacture in New Zealand

AS a sequel to the article by T. Hagyard, published in our February issue, on the possibilities of calcium carbide in New Zealand, it is worth recording that the New Zealand Government seems to be coming round to the idea of easing controls on electricity generation to help make it workable. Mr. Hagyard, who is senior lecturer in chemical engineering at the University of Canterbury, N.Z., tells us that the New Zealand Minister of State Electricity has expressed firm support for industries such as calcium and carbide, using South Island hydroelectric power. The Minister, with suitable Ministerial caution, expressed the view that 'it was possible that the Government, when satisfied as to the facts of any particular proposals, would, although possessing a monopoly in power generation, permit private generation of power for such purposes. The possibility was also accepted that, under certain circumstances, power from the State system might be supplied at favourable rates for such industries, but that in view of present capital commitments, the former procedure seemed to be favoured, especially if overseas capital were forthcoming for such private development.'

This statement was made after an approach by various industrial development and commercial bodies, and the chemical engineering department at Canterbury.

The South Island hydroelectric potential is thought to be around 7 million kw., of which the State will have developed 1,070,000 kw. when the Roxburgh and Benmore stations are completed by 1965. Raw materials for carbide are present, the solar salt industry could afford a source of magnesium-rich liquors for magnesium metal, Australian bauxite might be available for aluminium and interest is currently being taken in reported zinc ore deposits in Fiordland which may or may not make zinc production feasible.

It is hoped that development of industries such as these may result in export income to supplement the present undue dependence on farm products.

Silk screening up-to-date

THERE are more things in heaven and earth than are dreamt of in most packaging and despatch departments, so when it comes to marking drums, cans and other containers with the name or insignia of a product or company it is often thought to be a simple choice between using a stencil or paper label or having the container properly printed by the lithographic process.

There is, however, another alternative—silk-screen printing—which deserves much more attention than it usually gets. It can be done by hand or by using an automatic machine, according to the quantity of containers and the economics involved, and produces permanent marking in attractive colours which can be just as effective as 'litho'.

The basis of the system is a screen of silk, nylon or in some cases stainless steel, to which the design or wording is imparted, and this screen is stretched tightly on a frame. A suitable paint or varnish is applied to the upper surface of the screen so that when a squeegee is drawn over it and, at the same time, the drum or container is rotated underneath, the design is transferred to the container.

A range of machines is available, starting with the simple, bench-type unit for manual operation and going on to the semi-automatic and fully automatic types for all kinds of containers. One machine, the *Rondec* 303, deals with drums of 5 to 10 gal. capacity at the rate of 250 to 300 impressions/hr., and can be operated by unskilled female labour. The drums can be filled 2 to 5 min. after being printed, thus over-

coming the problem of storage space and enabling output to be equated with market demand. Another model, the 102, gives 600 to 900 impressions/hr. on such varied containers as paint tins, lipstick containers, cosmetic jars and electrical condensers. A clear impression is obtained even with wording in very small type.

Undoubtedly, with the present emphasis on automatic operation in continuous production lines, this method of marking has been too long overlooked.

Nitrogen looks to the future

WITH stocks of nitrogen fertilisers piling up everywhere, particularly in Western Europe, and prices declining, new production plant is still going up. What goes on? It seems that producers, especially the big chemical and petrochemical enterprises with plenty of capital to play with, want to make sure that they are all ready on the touch-line when demand, and with it prices, starts going up. They want to have ample capacity in regular operation when that time comes.

This picture is confirmed in a new quarterly publication of the British Sulphur Corporation Ltd. which sums up current trends in the production and consumption of nitrogen. It points out that much expansion of capacity, notably in Western Europe and Japan, is aimed at improving efficiency and thereby the competitive strength of old plant which no longer permits economic operation at prevailing low prices. The adjustment of production rates and the flexibility in the employment of plant capacities shows the determination of the major producers to keep the industry strong under the prevailing competitive market conditions.

The same publication refers, as an outstanding development in the industry, to the extension of the range of hydrocarbons used, whereby the industry has achieved more flexibility in the methods of synthetic nitrogen manufacture. Although coke-oven gas remains an important source of raw material, more and more nitrogen capacity is being based on natural gas, fuel oil and refinery gases. This diminishes the need to site nitrogen plants near economic sources of coal and coke.

The salient feature emerging from a broad review of world nitrogen production, consumption and trade is that the industry has trebled its level of operations in about 20 years. Current capital investment is about £1,000 million with an annual production capacity of some 11 million tons of nitrogen. These days, some 83% of world consumption is in the form of fertilisers, the remainder being used for industrial purposes. The greatest expansion in the nitrogen industry within the last 20 years has taken place in North America, where production has increased nearly seven-fold. Since 1945 the distribution of nitrogen capacity has been further effected by the erection of synthesis plants in many countries which formerly imported all their requirements and by the efforts of the Eastern bloc countries with their planned economies to achieve the highest possible level of production. Capacity in these countries now accounts for about 14% of the world total.

'Float' glass

SOMETHING of a revolution in glass production is promised by a process that results in a glass suitable for motor cars and other uses but in which expensive grinding and polishing processes are eliminated. After seven years' secret research and development, Pilkington Brothers Ltd. now have a full-scale unit producing bright, distortion-free glass in a ribbon 100 in. wide.

'Float' glass, as it is called, is produced by feeding a continuous ribbon of molten glass into a float bath where it flows on to a surface of molten metal to form a uniformly flat layer. The molten metal supports the glass while it is heated from above and below in a controlled atmosphere. Heating imparts a 'fire polish' to the glass, after which it is gradually cooled in a further section of the float bath. The glass enters the float bath at about 1,000°C. and leaves it at about 700, then passing on to the annealing section.

Pilkington are not saying what metal they are using as a support for the glass during the heating and cooling cycle and it would seem that they are still searching for a metal with the ideal chemical and physical properties.

The process is absolutely continuous right up to the finished ribbon emerging from the cooling lehr and, therefore, lends itself to a mechanised cycle from the handling of raw materials to packaging. There is also a saving in capital expenditure over a twin grinding plate-glass plant which, today, would cost more than £10 million in space and in maintenance cost and manpower.

Canadian chemical and engineering advances

ENCOURAGING results have been obtained in Canadian experiments on the production of citric acid by submerged fermentation of blackstrap molasses (low-grade cane molasses). Although a satisfactory fermentation has not yet been obtained, there have been yields of the order of 50% conversion of sugar to titratable acid (as citric acid). Trials have shown that the amount of ferro-cyanide required to treat the molasses is some 5 to 10 times that for beet molasses.

This work is referred to in the annual report of the National Research Council of Canada, which also records that, in another division of this organisation, a silver catalyst has been used in a study of the oxidation of ethylene and propylene. The work involved the rates at which chemical change takes place, the mechanism by which the reaction proceeds, the effect of modifiers on the products formed, and the development of analytical procedures to separate trace quantities of products. Dehydrogenation of other petroleum products has been studied on semi-conducting oxide catalysts and attempts made to correlate the electrical properties of the catalyst with its chemical activity.

An extensive study of the kinetics of the polymerisation of styrene and methyl styrene initiated by sodium naphthalene has been made. This has allowed polymerisation equilibria and appropriate thermodynamic properties to be determined. Fractionation of polymers using chromatographic methods has made possible the assessment of molecular weight distributions in polymer

samples. An investigation of the oxidation of acetoin to biacetyl by ferric ion has been completed.

Chemical engineering research and development work has included the oxidation of ethylene to chemical intermediates, the activation of clay used in contact bleaching of oils and the cracking of highly viscous petroleum oils, sedimentation of suspensions and potential application of the newly developed spouted-solids technique for contacting fluids and solids.

In the corrosion field, oxidation rates of pure iron and some of its alloys have been measured over a range of temperature by following weight gains and by cathodic reduction of the oxidation products. The oxides formed were identified by chemical analysis and by electron and *x*-ray diffraction. This has made possible estimates of transformation and diffusion rates among the various metal oxides present. Since it was observed that oxidation behaviour of metals is largely dependent on their surface condition, reactions of oxygen with surfaces prepared by mechanical polishing, electropolishing and by chemical etching are being compared.

Films formed on iron in deaerated water containing nitrite have been studied to gain information on the mechanism by which nitrite inhibits corrosion. Preliminary studies have been made on corrosion rates of magnesium by following the electrical resistance and capacitance of the films formed. Attempts are being made to measure the activity of ferrous oxide in molten slags and of oxygen in steel by electrochemical methods. The rate of oxidation of carbon in steel is being measured and appears to be a first-order reaction with respect to oxygen.

The report urges an increase in Government financial support for scientific research in Canadian universities as well as an expansion of research by Government laboratories and by industry.

Inexpensive flow metering

IN India, where scientific research and development often has to be done on a 'shoe-string' budget, some ingenious ideas are produced for saving money on plant and apparatus. One recent example is an easily constructed flowmeter which works roughly on the lines of the well-known *Rotameter* but in which there is no need to have a tapered glass tube. The tapered glass tube of the *Rotameter* is a most important part of the instrument and if such tubes are to be replaceable they have to be very carefully manufactured to ensure the dimensions are exactly the same. At the A.C. College of Technology, University of Madras, they got the idea of constructing a flowmeter which works on a glass tube and float system like the *Rotameter*, but in which the tube, instead of being tapered, is of uniform bore. The variable area is achieved by having a tapered cone of metal inside the tube, narrow end uppermost, and round it an annular float which moves up and down the tube. Result: Most of the flow is between the tapered rod and the float, and the instrument gives reproducible results.

They tried out floats of both nozzle and orifice shape, with brass and aluminium as alternative materials of construction. The experiments were described in *Trans. Indian Inst. Chem Engrs.*, 1956-57, 9, Part 2, pp. 25-31, by M. G. Subba Rau, who gave data obtained in calibrating the instrument, using water and air.

A new step to steel

A FILM on the Mexican plant for making sponge iron using a reducing gas instead of coal or coke, shown in London recently, reveals that some unusual engineering features go with this unusual process. Most impressive, perhaps, is the way in which, after the reduction has taken place, the bottom part of the reactor, which holds about 30,000 lb. of iron ore, can be detached from the upper section and moved along guiding rails to be tipped, becoming in effect a huge, travelling skip. At the Monterrey plant, where there are five reactors all at a different stage in the process cycle at any given moment, this operation of dumping the hot sponge iron from a reactor into a hopper ready for transportation to a melting furnace takes place about once every hour. The same labour crew can attend to all reactors, dumping operations being controlled from an outdoor platform. The reduction process itself, for all reactors, is controlled from a central control house.

For this process, briefly described in our November 1958 issue (page 382), the reducing gas is obtained from natural gas and contains some 85% of hydrogen and carbon monoxide, the rest being carbon dioxide, methane and water vapour. The natural gas is first desulphurised and passed through a high-pressure steam reforming furnace. The reaction cycle takes four hours, with an extra half-hour for dumping and charging. Final ore reduction takes place within a temperature range of 1,600 to 1,900°F. The Monterrey plant, which produces 200 long tons/day of sponge iron, needs about 21,000 standard cu.ft. of natural gas per ton of reduced ore. A second plant that is being planned for Mexico will have a capacity of 500 long tons/day and will have substantially lower utilities requirements, improved thermal efficiency, and improved operating economics. It is believed that far larger plants are practicable.

The sponge iron yielded by this process may be substituted for pig iron or scrap in making steel. It thus offers the possibility of developing a steel industry in countries where they are short of coking coals for ore reduction, where it would cost too much to operate a basic steel industry using imported raw materials, and where the scale of steel production envisaged would not make it economical to operate a blast furnace. The M. W. Kellogg Co., who are licensing agents for the process, say that ores with a high percentage of fines (and therefore difficult to handle in normal blast-furnace operations) may be reduced to metallic iron and, by the addition of a briquetting operation, sold as a high-quality metallic feed.

The *HyL* process, as it is called, was developed by Hojalata y Lamina S.A., a Mexican steel-producing enterprise, with engineering assistance from M. W. Kellogg.

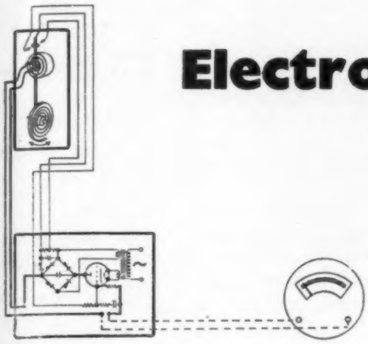


Fig. 1. Principle of electronic force-balance transmitters.

Electronic Process Control —Advantages and Scope

By C. W. Cawthorne

(Evershed & Vignoles Ltd.)

The controversy continues between the advocates of pneumatic and those of electronic systems for measuring, transmission and control of process variables. Both systems offer many advantages, including data reduction and computation, but electric transmission certainly scores where long distances are involved. The case for electronic systems is here made by reference to numerous examples of what can be done and what advantages can be obtained.

THE first comprehensive electronic process control scheme was installed in an oil refinery in 1951 and was of British manufacture. Since that time a number of electronically controlled plants have been commissioned in other industries—thermal power, steel, chemicals, sugar—both by British and American firms. Before these installations, pneumatic process control was used almost exclusively and it is obvious, therefore, that some comparison of the two control media must be made on technical, operational and economic grounds. The plant process control engineer is faced with a decision between the two types of equipment, and he must demand a clear and unbiased balance sheet.

In drawing up this balance sheet, it is important to make a comprehensive assessment and, although the advantages and disadvantages of the two systems have been listed many times, the wider issues have not been sufficiently stressed. It may be said that any pneumatic item of equipment has an opposite number, performing the same function, giving a comparable performance but based on an electronic principle. This 'anything you can do I can do better' approach does not give a true comparison. If a control scheme designed for pneumatic equipment is taken and electronic components substituted, item for item, few advantages will result. The major advantages of the new medium are obtained when its possibilities are appreciated and exploited fully. What is really required is a new and different approach to the control problem.

Before going into the relative merits of the two types of equipment, it is desirable to explain the principle of operation of a typical electronic process control system, as this system will be used to illustrate the features of this process control medium.

Transmitters

All transmitters are based on the same principle, irrespective of the type of measured variable, or its range. The variable is converted into a force, which is applied to a pivoted beam, as shown in Fig. 1. This beam also carries a transductor coil, working in the field of a permanent magnet, to provide the feed-back signal; and a contact, free to move between two fixed contacts, so that it signals any unbalance of the beam.

The system works on a force-balance principle, the force produced in an instrument by the measured variable being balanced by the feed-back force. If this balance is upset, the contact on the beam touches one or other of the fixed outer contacts, which are connected to positive and negative potentials. This modifies the current through a thermionic valve which is fed to the coil on the beam to produce the feedback force. The valve thus acts merely as an infinitely variable resistor, and its output current is an analogue measurement of the measured variable, irrespective of changes in supply voltage, frequency or output circuit resistance. This current is used to operate indicators, recorders and/or integrators, and is also applied as the measured value input to the process controller.

The type of transducer which converts the measured variable into a force on the beam varies according to the purpose of the instrument. For pressures, bourdon tubes, bellows or diaphragms are used; for flow, differential diaphragms or bellows.

In this system, the transmitter is mounted on the plant, adjacent to the measuring point, whilst the power unit, which contains the electronic valve and associated components, is accommodated in the control room.

Controller and actuation

The process controller accepts the measured value in the analogue form of direct current, modulated by the transmitter.

This signal is amplified and its voltage compared with a desired value to give an error voltage, which is used to operate the proportional, integral

and derivative terms of the controller. These terms are summated in the output stage as direct current to operate the valve positioner or other actuators.

It can be seen from the circuit diagram in Fig. 2 that the three terms are produced separately in this non-interacting process controller. Remote hand control and smooth change-over facilities are included.

The d.c. output signal at low power level from the process controller is required to position the regulator. Regulating units vary greatly on different types of plant, from small balanced valves, which require an operating force of a few pounds, to heavy unbalanced slide dampers, weighing several tons. The valve positioner must be capable of providing the operating force at a high speed. (The speed of response must not be limited to that of the positioner.) Therefore it must possess suitable servo characteristics and, if possible, be self-contained. An electro-hydraulic valve positioner meets these requirements adequately.

Electronics versus pneumatics

The advantages of the electric medium may be listed as follows:

Time lags. Transmitters can be located adjacent to the measuring points so that time lags in intervening pipes are negligible. Time lags between transmitters, controllers and positioners are eliminated, as these connections are electric.

Transmission. Errors due to buoyancy or temperature gradients along pipes are negligible. This is particularly important when measuring very low static pressures, *e.g.* in furnaces, when buoyancy errors in long pipes can become significant.

Centralised instrumentation. Grouping of supervisory instrumentation on one central panel for a works or plant is facilitated. In a large plant such centralisation implies long transmission distances which can only be bridged electrically. For example, in a large iron and steel works it is desirable to centralise all fuel measurements so that a continuous balance can be maintained between fuel demand and supply. One works in the U.K. has buildings over five miles apart, so that transmission distances may be of the order of miles.

Centralisation in most cases also implies miniature instruments to reduce the overall size of the panel. Electric indicating and recording instruments readily lend themselves to this. A typical centralised graphic panel is shown in Fig. 3.

Supply plant. Large pneumatic control schemes demand main and standby compressor plant. Not only is this a major item of capital cost, but the running costs of compressing, filtering and drying large volumes of air are significant. In cold climates there is the hazard of freezing. The electro-hydraulic positioners used in the electronic process control scheme are self-contained, with closed oil circuits; the transmitters and controllers draw their power directly from a.c. mains.

Failure to safety. The hydraulic positioners in an electronic process control scheme can be made to open or shut the valve on failure. This performance is similar to that of pneumatic positioners. In addition, however, the use of an oil circuit permits a positive lock of the regulating unit on failure, if required.

Installation costs. The use of multicore cabling techniques in the interconnections between transmitters, valve positioners and control panels results in a considerable reduction in installation costs, as against comparable air circuits.

Maintenance. The extensive use o plug-in components and sub-assemblies enables the process control equipment to be kept in service for the maximum possible amount of time. Although plug-in techniques have been applied to pneumatic equipment, the mechanical difficulties prohibit their universal use. Electronic equipment does not require maintenance staff of so high a calibre; it lends itself to simple tests which trace the fault to a single component or printed card, which then can be replaced.

For example, a valve can be plugged into a tester which has a test indicator calibrated with sectors marked 'serviceable' and 'replace.' If the pointer reads in the 'replace' sector, the valve can be discarded. The wider use of printed circuit cards and potted components will ultimately reduce the costs of these so that they can be thrown away when a fault develops.

Capital costs. At present, the cost of an electronic scheme is comparable to an equivalent pneumatic one, but the amount of pneumatic equipment sold today is vastly greater than of electronic; it is reasonable to assume that the increase in the sales of electronic equipment will, in time, bring its prices below that of the pneumatic one. Electronic equipment can use mass-produced components such as valves, resistors and condensers and a minimum of precision mechanical components; with judicious use of printed circuits it can be assembled by relatively unskilled labour.

Isolation of transmission circuit. This is particularly important on nuclear plants. A leak on a pneumatic line can discharge radioactive air into a control room in a nuclear power station. With suitable insulating materials, the transmission cables of an electronic system can be located in areas of high radiation level. In fact, some insulating materials improve their properties on irradiation.

Flow rate measurement

In the following paragraphs some examples are given of the ways in which combinations of electronic units can be made to enhance the quality of control loops. It is admitted that some of these arrangements can be achieved pneumatically, but only by employing clumsy and complicated mechanical arrangements. The strength of the

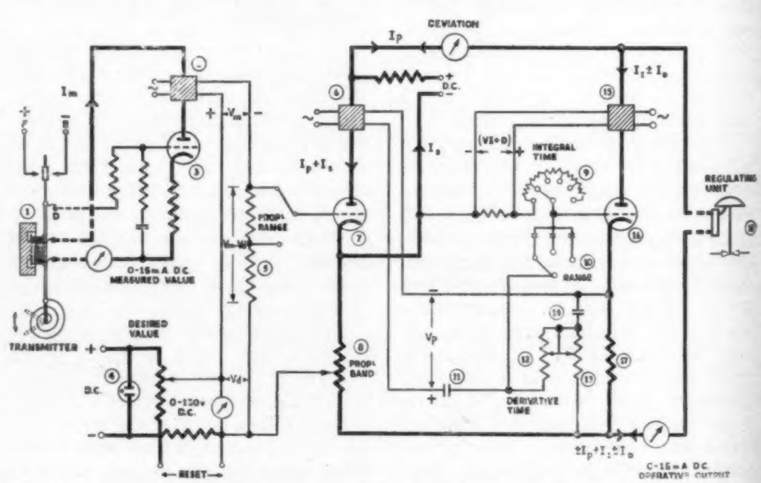


Fig. 2. In an electronic process controller, three non-interacting terms are provided by means of the circuit shown here.

electronic medium lies in the fact that these additional facilities can be obtained simply and in many cases without the use of additional equipment.

The quality of any automatic control loop cannot be better than that of the primary measurement. Any improvement in this must, therefore, be of paramount importance. In flow measurement, the differential pressure produced by the primary device (orifice plate, venturi or pitot tube) varies with the square of the flow. As the rate of flow is often inferred from differential pressure, it is convenient for the output signal from the transmitter to be a linear proportion of the rate of flow. This is of particular importance when flow summation or difference is required. With the electronic flow transmitter this square root compensation can be achieved without the use of cams or cam followers.

One electronic flow transmitter is shown in Fig. 4. It is based on the force-balance principle previously described, the differential pressure being applied to a diaphragm which produces a force on the beam balance. In this case, the opposing force is produced by a coil working in the field of an electromagnet. As both the coil and the electromagnet winding are energised in series by the output current, the feedback force is a function of the square of the output current. At force balance, this is equal to the input force and, hence, the differential pressure:

$$h = i^2 \text{ and hence } \sqrt{h} = i = Q$$

where h = differential pressure, i = output current and Q = rate of flow.

Mass flow

The relationship between rate of flow and differential pressure produced across the orifice plate is only correct for the pressure and temperature conditions for which the plate was designed. On many plants conditions vary over wide limits and, if an accurate flow control loop is required, measurements must be compensated for these changes, *i.e.* a measurement of mass flow must be made. The equation

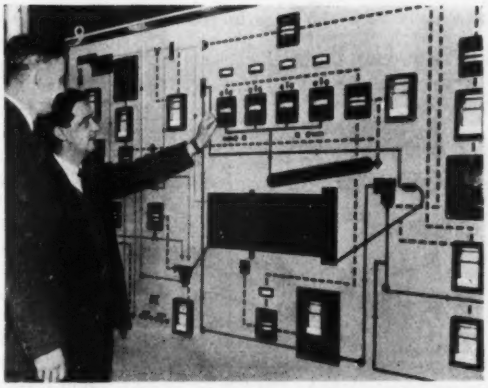


Fig. 3. Electronic indicators and recorders lend themselves to compact designs as on this central graphic control panel.

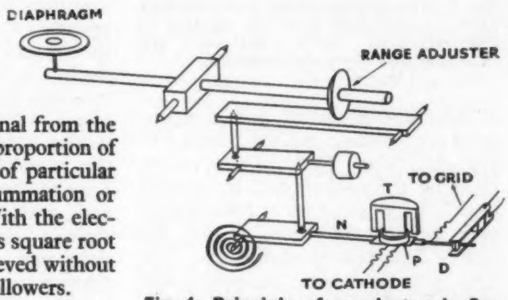
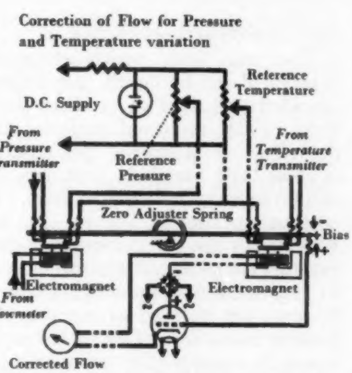


Fig. 4. Principle of an electronic flow transmitter, based on the pressure differential measured.



NOTE: *The above Pressure and Temperature Transmitters measure the variation from their respective Reference Levels. At Reference Levels Corrected Flow equals Measured Flow.*

Fig. 5. With electric signals it is easy to compute desired information directly; in this case mass flow.

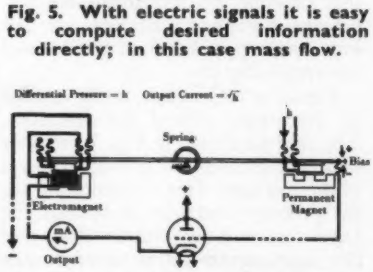


Fig. 6. Another simple computer extracts square roots.

relating these variables may be simplified to:

$$Q = C\sqrt{\frac{hP}{T}}$$

where Q = rate of flow, C = a constant, h = differential pressure across orifice, P = absolute pressure, T = absolute temperature.

The variables h, P and T are measured by transmitters which produce direct current signals, proportional to the measured values (usually P and T are measured as gauge values and reference currents added to convert to absolute units). These currents are then applied to the simple computer shown schematically in Fig. 5. This unit is based on the same principle as the transmitter, but, in this case, the forces on the beam are produced by coils working in electromagnets. The output current is adjusted by the contacts and valve to maintain the force balance. Torques about the pivot may then be equated:

$$h \times P = T \times i \text{ or } i = \frac{hP}{T}$$

where i = output current.

Square rooting by a second computer gives

$$Q = \sqrt{\frac{hP}{T}}$$

using a series-fed coil and electromagnet, as described in the previous paragraph. Fig. 6 shows this second computing unit schematically.

The above formulae are based on the assumption that the fluid obeys the perfect gas laws. This is usually a fair assumption over the ranges of pressure and temperature experienced on most plants. Over wider ranges, the simplified equations must be modified into a somewhat more complicated form.

Level measurement

The weight of the fluid contents of a tank can be inferred from a measurement of the level. A variety of methods of level measurement are available, depending upon the pressure in the tank, the fluid and other operating conditions. Sometimes the level is inferred from the hydrostatic head and measured as a pressure (or differential pressure). The output signal of the transmitter can then be calibrated in weight units. This calibration is only correct for one value of the specific gravity of the fluid and if this changes (owing to changes in pressure, temperature or fluid gravity), errors in weight measurement will result.

The transmitter used is similar to the one described earlier; and the level is transduced into a force, which is applied to the pivoted beam. The output of this transmitter is thus a d.c. signal, proportional to level. A second d.c. signal, proportional to specific gravity, is produced by a transmitter of the displacer type, and these two signals are applied to the simple computer, described earlier, which solves the equation and produces a true weight signal.

Multivariate functions

In many applications it is desirable to generate a function of two or more primary measurements as the input to the process controller. A simple example of this is flow summation (or difference). This can be achieved merely by adding the d.c. output signals from a number of flow transmitters.

For combustion control, for instance, it is necessary to produce a measurement of the fuel flow/combustion air flow ratio to a furnace. The simple computer in Fig. 5 can be used for this problem.

In a specialised form of combustion control of a pulverised fuel boiler, the steam flow is taken as a measure of heat released and, hence, the fuel input to the boiler. Steam flow S and air flow A are measured by flow transmitters, and the output currents from these units are connected to the coils on a computer beam. A current K is also used to introduce a constant into the equation and to modify the ratio over the flow range. The output of the computer

$$\frac{A - K}{S}$$

can be either indicated or used for combustion control.

Heat and heat flow

The B.Th.U./min. produced by a hot-water central-heating plant can be calculated by the product of temperature difference between flow and return mains and rate of water flow. The temperature difference and rate of flow are again applied to a simple computer as d.c. signals and the output is a measure of heat per unit time. A constant is introduced into the equation to represent the specific heat of the water at the operating temperature.

This heat flow measurement has been extended in a nuclear research plant to measure the heat output of a gas-cooled nuclear reactor. This reactor had four inlet gas ducts and 14 outlet ducts. In each duct the rate of flow was measured and compensated for pressure and temperature to give mass flow. This was then multiplied by temperature and by specific heat (a linear function of temperature over the working range), to give the rate of heat flow in each duct. The inlet heat flows were summated and subtracted from the summated output heat flows to give the heat output of the reactor.

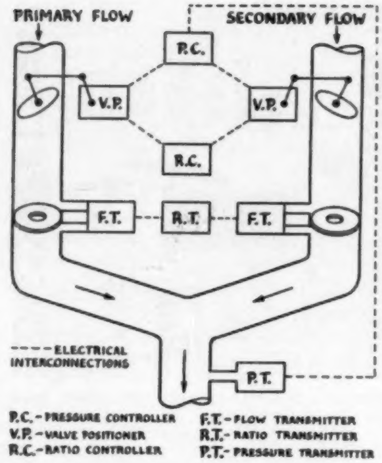


Fig. 7. This arrangement provides flow ratio control with pressure control of the mixture. Both regulators are operated by both controllers.

Comprehensive schemes

The ease with which electronic equipment can be linked, interlocked, cascaded and used to produce functions of the measured variables has the effect of increasing the number of measured variables that can be employed in a single control loop. In combustion control, the gas and air flow signals can be pressure and temperature compensated, and can be used to generate a flow ratio signal which, in turn, can be used as input to the process controller. This ratio can be trimmed automatically on a calorific value measurement, or a measurement of oxygen content of flue gases. In this example, no less than nine significant measured variables are fed into one loop with one controller and one regulating unit.

Similar arrangements can be applied on the output side of the controller. The scheme shown in Fig. 7 provides flow ratio control with pressure control of the mixture. It is conventional for the pressure controller to operate the regulating unit for primary flow, and the ratio controller to regulate the secondary flow accordingly. But in the arrangements shown the two regulating units are operated by both the pressure and the ratio controller. The former moves the two valves in the same direction and the ratio controller moves them in the opposite directions. This arrangement gives a fast and stable control, as the pressure controller would, by itself, maintain a correct ratio if the valves were properly matched over the range and if the upstream pressure remained constant. The ratio controller then merely has to compensate for such variations.

Regulation

The conventional method of fluid flow control is to use a suitably characterised control valve and to regulate flow by varying the pressure drop across it. This is an inefficient method, as a considerable amount of pumping power is absorbed as pressure loss in the control valve. A more efficient method is to regulate the pump speed to meet the instantaneous fluid demand. Speed control of a.c. pump motors is not an elegant solution, but slip couplings are now available to meet the problem. The slip couplings are based on an electromagnet principle and, with a constant speed drive, the pump speed is a function of the current input to the coupling. The output of an electronic process controller can be fed directly into the electric control unit of the coupling.

Considerable savings in capital costs (in addition to running costs) are possible with this arrangement. Pressure vessels and piping can be designed for lower working pressures, as the supply pressure can be reduced when the pressure drop across the control valve is eliminated.

Other control features

The output current signals from the transmitters are analogue measurements of the variables. These signals can conveniently be fed into any data reduction equipment as voltages across standard input resistors. Expensive input conversion stages are not required and input scanning of the measured variables is facilitated.

In the ever-increasing complexity of modern plants a major requirement is easy supervision of control loops and, for this purpose, a deviation indicator is desirable. This may comprise a moving coil indicator, illuminated from the rear and having a horizontal bar pointer moving behind a ground glass plate. The indicator, which has a centre zero, is inserted in the feedback circuit of the process controller. With the measured value

(*Concluded on page* 161)

Level Control by Gamma Rays

This article describes a system of level control, developed over the past few years, in which all the components are mounted outside the vessel, and which is thus particularly suitable in conditions of high temperature or pressure, corrosion or abrasion.

By N. H. Lowden

(*Isotope Developments Ltd.*)

FOR 'on-off' control of level, the gamma-ray system consists of a suitable source of radiation, a Geiger-Muller counter tube, and an electronic unit converting the counter output to a useful electrical signal. The gamma-ray source is usually Cobalt 60, with a half-life of 5.25 years, or Caesium 137, having a 30-year half-life. These isotopes are mounted in screening holders designed to reduce radiation to safe levels in all directions during transport, and having at the front a shutter which can be opened to allow the full beam to emerge over a small solid angle once the holder has been installed. The Geiger-Muller tube is of the halogen-quenched type, operating at about 400 v., and the electronic unit comprises a simple pulse-rate meter and control relay. The counter tube and the remainder of the electronic components are mounted together in a weatherproof or, if necessary, a flameproof enclosure, and can be operated in temperatures from about –20 to +60°C. Where higher temperatures are encountered on the outside of vessels, it is normal practice to mount the counter tube together with a cathode-follower unit in a water-cooled holder. The rest of the components are remotely positioned in a separate enclosure.

To provide 'on-off' control it is simply necessary to mount source and detector units at the critical level on opposite sides of the vessel. The source activity is calculated so as to give a count-rate of from 50 to 100 per second in the detector when the vessel contents are below the critical level, and the activity necessary will therefore vary for each application, depending on the nature and thickness of the vessel walls and the total distance between source and detector units.

When the vessel contents rise to the critical level, the radiation reaching the detector is reduced to a degree depending upon the amount and nature of the material now present in the beam. Except in the case of vessels only a few inches in diameter and containing material of very low density, the reduction in signal at the detector is always sufficient to cause the control relay to operate and thus to provide external indication or control of the altered condition within the vessel. The method may therefore be said to be substantially independent of the nature of the vessel contents.

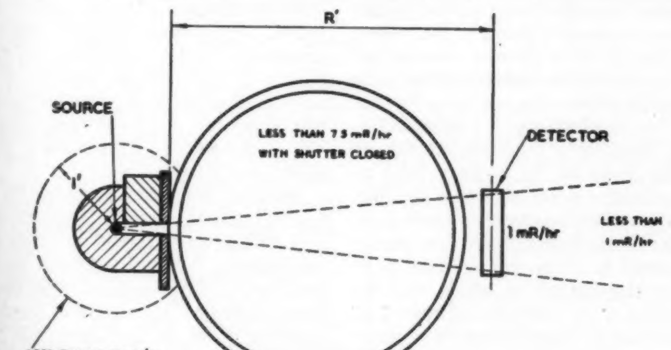


Fig. 1. A tank equipped with a gamma-ray level detector, showing maximum radiation levels.

Response times

Owing to the random nature of radioactive emissions, the detector signal has always a statistical fluctuation and for this reason it is necessary for the electronic unit to integrate the incoming signal over a definite period of time. This is normally referred to as the response time of the system, and in the simple device already described it is usually fixed at 8 sec.

Response times of 1 sec. or less are possible where necessary because of very rapid level variations, but they can only be achieved by increasing the signal level at the detector, and therefore require more source activity.

Accuracy

The accuracy attainable with this method of level control is within $\pm\frac{1}{4}$ in. provided that the top profile of the vessel contents remains flat; with liquids in violent agitation there will naturally be some loss in control accuracy. Fig. 1 illustrates a typical installation in diagrammatic form, and also indicates the maximum radiation levels normally reached in the vicinity of the radioactive source. It is important to keep these levels as low as possible for health reasons and, although it is not possible in an article of this length to go into this subject very fully, a brief statement on radiation hazards will be found at the end.

Continuous indication

Where continuous indication of level is required, it is possible to achieve this by using gamma radiation, but experience has shown that the method can only be applied satisfactorily over a comparatively short range of level change. Fig. 2 illustrates a number of methods in which the rise and fall of vessel contents is used to produce a varying signal in a detector. The electronic unit associated with the counter is more complicated than in the case of the simple 'on-off' control system, since it is now necessary to convert the detector signal to a continuously varying d.c. output for display on a meter or recorder. The main difficulty with these methods of continuous indication is that the calibration curves are not always linear and, furthermore, it is always necessary to carry out initial calibration by making exact determinations of the content level over the whole range which the instrument is required to cover. In the case of Fig. 2 (*a*), it will be seen that the calibration remains linear over the range, but long vertical sources are difficult to shield and long Geiger counters are not readily available commercially. For these reason installations of this type are limited to a maximum range of about 3 ft.

Where continuous indication over a long distance is essential, the best practical method is to employ a simple 'on-off' system as already described, and to arrange for both source and detector units to be driven together up and down the vessel. The driving gear can be controlled by a reversing motor so that the source and detector units will follow changes in level and always come to rest in line with the surface of the contents. For large vessels this method would necessitate a costly mechanical and electrical installation, and has not so far been applied in practice, although trial installations have been operated on a small scale.

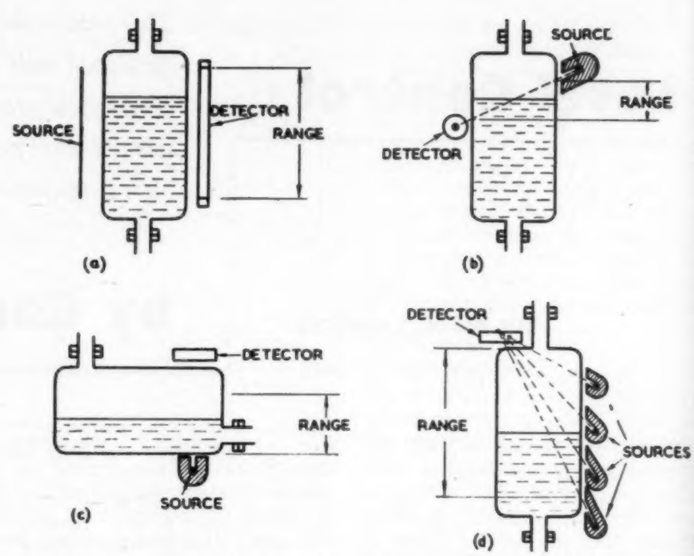


Fig. 2. Alternative schemes for continuous level indication over short ranges.

Control of glass melting

In cases where an extremely accurate indication of level is required over a very short range, the method is ideal and is now practically standard for the control of molten glass level in melting furnaces. These furnaces normally contain a large quantity of glass at a temperature of about 1,100°C., and this is fed through one or more channels to various bottle-making machines. The level of glass in the channels must be maintained constant, so as to ensure that the raw materials are being fed to the furnace at a rate equivalent to that of the output. It is also essential that the size of glass 'gob' released from the end of the feeder channel to the moulding machine should not vary because of changes in the hydrostatic head. It is usually considered necessary to control glass feeder level to within $\pm\frac{1}{16}$ in. and also to indicate extreme deviations which may occur up to $\pm\frac{1}{2}$ in.

Fig. 3 shows a cross-section through a typical feeder channel, the walls of which may consist of 5 or 6 in. of refractory brick with a similar thickness of insulating brickwork and a mild steel casing. The internal width of the feeder may be about 18 in. It will be noted that the source unit and water-cooled detector units are mounted on either side of the feeder channel in such a position that when the glass level is correct one-half of the horizontally mounted counter tube is shielded from the radiation by the glass itself. Any slight rise or fall in glass level will therefore shield or expose more of the counter tube to the radiation beam and thus produce a decreased or increased output signal.

The signal from the detector unit is connected to a remotely mounted ratemeter, the output of which may be displayed on a recorder calibrated in fractions of an inch. When the counter is horizontally mounted a linear calibration is obtained over a total range of $\frac{1}{2}$ in., and the indicator can be easily read to within $\pm\frac{1}{16}$ in. Using a vertically mounted detector tube the calibration can be made linear over a wider range, but with some decrease in accuracy. This instrument provides an obvious subject for automatic control, and equipment for this purpose is now becoming available.

Safety considerations

It is obviously desirable that an instrument designed for automatic control in industry should fail to safety or provide an immediate indication of breakdown. In the case of instruments depending upon gamma radiation for their operation, advantage is taken of the fact that there is always present a small natural background of radiation, both from natural radioactivity and cosmic rays. The detector unit should therefore, if functioning correctly, provide at all times a small background signal irrespective of the level conditions existing within the vessel. This signal can be arranged to maintain a relay energised so that failure of the counter tube or of its associated amplification circuits causes this relay to drop out and actuate alarm signals or, if necessary, shut down the process.

Mention has been made earlier of health hazards associated with the use of radioactive materials in industrial installations. These hazards are of two kinds; the danger of ingestion or contamination from active material escaping from its container, and the dangers due to exposure of the body to external radiation. The first of these risks can be eliminated by using standard radiographic source capsules which are provided by the Atomic Energy Research Establishment, Harwell, in the case of Cobalt 60, and the

Radiochemical Centre, Amersham, in the case of Caesium 137. These capsules are carefully sealed so that no escape of the active material is possible, and the pellet itself is then enclosed in an aluminium or stainless-steel holder provided with a tag carrying a serial number for identification purposes, and used also for securing the source in its shielding holder.

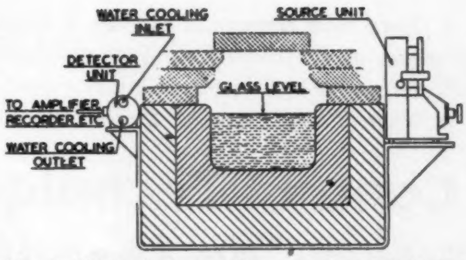


Fig. 3. Method of mounting source and detector units on glass feeder channel.

The second risk is dealt with by enclosing the source capsule in a thickness of lead sufficient to attenuate the radiation to a safe level. Regulations are at present being drafted to cover industrial radiation hazards and it is expected that a maximum level of 2.5 mR/hr. will be laid down for continuous exposure throughout the working week, with 7.5 mR/hr. as the maximum permissible level for intermittent exposure.

The detector tubes of the instruments already described are all capable of operating at dose rates of 1 mR/hr. or less, and the source activity for each application is therefore chosen to give approximately this level at the detector unit. There is therefore no need for any precautions whatsoever on this side of the installation. It is also normal practice to design the source shielding holders so that the external radiation around the back and sides is not greater than 7.5 mR/hr. at 1 ft. from the source. Within the vessel itself there will be a comparatively high intensity of radiation at the source unit side, and this will decrease in accordance with the inverse square law as it passes to the detector side. Since it is frequently necessary to permit workers to enter vessels from time to time for cleaning purposes, it is essential to ensure that the radiation beam is cut off at the source holder during these maintenance periods. The shutters provided for this purpose are normally designed so that when closed the radiation at the front of the holder is no greater than that present on the back and sides.

It should be emphasised that gamma radiation of comparatively low intensity, as employed in all these instruments, cannot alter the physical or chemical nature of material through which it passes, nor can it render such material radioactive.

It is hoped that this article will assist in introducing the instrument engineer to a new, safe and comparatively inexpensive method of level control which can be particularly valuable in cases where more conventional methods are unsuitable.

Electronic Process Control

(*Concluded from page* 158)

at set point, the indicator shows a horizontal line at mid-scale; positive or negative errors cause the pointer to move either up or down scale. In a large plant, a number of these indicators are mounted side by side. This in-line display gives an unbroken horizontal line at mid-scale for steady conditions and deviation in any control loop is immediately obvious as a break in the line of indication.

An extension of this principle is deviation alarm and lock-out. For the former, the deviation indicator is backed up by an alarm relay, which brings on an audible or visible alarm when the deviation exceeds prescribed limits. The system can be further extended to override the automatic controller and to lock the regulating unit in its last working position. This is achieved by shorting out the proportional stage of the controller by the alarm relay contacts and the integral stage then maintains the controller output steady at the value obtaining immediately prior to the alarm.

Batch processes and automatic start-up of plants also bring special control problems. The inherent 'integral limiting' of the electronic controller facilitates the solution of these problems. The integral stage of the electronic controller can also be primed to enable a plant to be brought up rapidly to the desired value on automatic start-up whilst, at the same time, retaining the long integral time setting required to suit the plant operating characteristics.

Plant simulation

In the past, automatic control systems have been set up on site according to empirical, rule-of-thumb methods, hoping that the plant will fit into the control loop. To achieve optimum results, it is necessary to do a large number of tests which must include introducing disturbances into the plant at all throughputs over the range. Plant managers are generally not too pleased about protracted commissioning trials of this type and all too often the controller adjustments are based on one or two spot checks over a narrow range of plant throughput. As a result, the optimum settings cannot be found.

Electronic process control plant can be simulated by a suitable network of resistors and condensers and this simulator can close the loop in the test room where there is no limit to the time available for optimising controller settings.

This more scientific approach to controller commissioning is facilitated by the fact that the electronic controller has pure and non-interacting terms with high repetitive accuracy of performance from any adjustment.

Future plants will be designed with automatic control in mind and the dynamic response characteristics will be predictable. When these data are available, any plant will be capable of simulation.

The above list of examples is by no means exhaustive, but shows some of the experience to date on new slants in process control introduced by the electronic medium.

Using as an example the control of liquid flow through a pipe by a simple pneumatic instrument, the author shows how the various modes of control arise out of different conditions and types of system. Proportional, auto-reset and derivative arrangements are discussed, with particular reference to effects of instrument sensitivity on stable conditions.

Pneumatic Control Techniques and their Effects on Stability

By H. W. Stoll

(*Taylor Instrument Co., U.S.A.*)

THIS article will limit its treatment to air-operated controllers and will deal specifically with the functions they can perform and the reasons for their use.

A typical air-operated control circuit is shown in Fig. 1. Here we have a flow controller and a diaphragm valve, located downstream from the flowmeter orifice. In practice, the variable need not be flow. To do a satisfactory job, the controller must transform an air pressure to a value which, when made to act on a diaphragm valve, will cause it to open and permit the flow of fluid at the desired rate.

Let us assume that this controller has become stabilised and is holding the flow at 50% of maximum. Suddenly the line pressure is increased by 10%, due to pump pressure control action which, in turn, results in a greater flow rate, since there is an increased pressure drop across the control valve. As flow increases, the controller causes its output air pressure to change, thus closing the valve until it reaches stability at a new, higher value.

This controller's effort is directly related to the flow change, so that it gives a proportional response.

Effect of sensitivity

Its operation will be clear from Fig. 2. Air is introduced through a small orifice to a nozzle which directs it at the baffle. A back pressure is developed as a function of the distance between the nozzle tip and the baffle. The arrangement is highly sensitive, as is evident from Fig. 3: the back pressure changes appreciably for a very small change in distance, and controls an air relay valve which multiplies any change in this back pressure by a fixed amount.

This amplified pressure change is sent to the diaphragm valve and also to a bellows which, through a lever system, re-positions the nozzle, relative to the baffle. If the bellows was located at the lever's fulcrum, then no nozzle follow-up would occur, and the output pressure would change very rapidly with change in flow.

On the other hand, as the bellows element is moved to the left, more follow-up action occurs, and the variation in spacing between the nozzle and baffle is less, which, of course, results in a proportionately smaller change in output pressure.

As the sensitivity is increased, the flow change discussed earlier causes a greater output pressure change which, in turn, increases the valve stem travel, so that the new stable flow position is nearer the former value. On the other hand, if the controller sensitivity is decreased, then this same flow change causes a decreased change in valve position and makes the new control position deviate even further from the original one.

Since the controller has to hold the flow to a specified value, regardless of line pressure changes, it is desirable to increase the sensitivity so as to minimise the deviation from the set point. At the same time, because of inertia and the ability of the instrument to respond to flow changes, there is a maximum limit of sensitivity which can be set if stability is to be achieved. Otherwise the controller will be over-enthusiastic in its corrective efforts and go into oscillations. Fig. 4 (left) shows a typical chart record of this condition. If the sensitivity is near the limit, a long recovery time is required and, if further reduced, it will follow the pattern shown on the right. This is the desirable setting. It has been proved that the sensitivity should be about one-half of that setting which

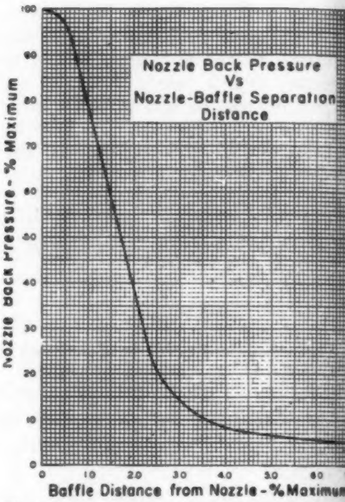


Fig. 3. Proportional over a considerable range of control pressure, this graph illustrates the high sensitivity obtained.

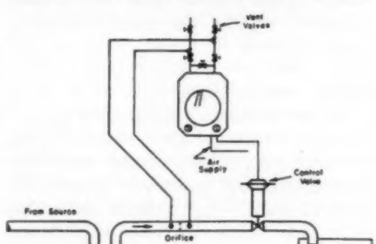


Fig. 1. The basic circuit, using an orifice flow meter and pneumatic signal transmission to a linear valve.

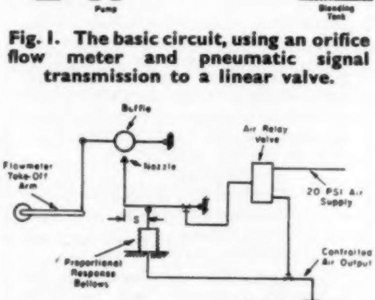


Fig. 2. How the controller acts to give proportional response by means of a single bellows.

causes the controller to oscillate in steady rhythmical fashion, each wave being identical in shape and dimensions.

Automatic reset

Let it now be supposed that a supply tank is added to the pump intake line, as shown in Fig. 5. This tank is filled periodically so that the pumping rate will depend somewhat on the level. The quality of the product in the mixing tank depends on the constant addition of fluid, and any deviation from the flow controller's set point would prove harmful to the product. Yet, this is exactly what would occur, using a flow controller with its proportional response, because of the varying hydrostatic head above the pump. To overcome this effect, one must alter the design of the controller so that it will always strive to keep the control point and the set point coincident. This added feature is termed automatic reset, because it continuously resets the varying control point until it returns to the original or set point position.

As the pressure head drops, there will be a change in air pressure and the valve opening will increase but the control point will drift toward zero flow. An automatic reset will cause the valve to open more than the proportional response requires, and will continue this action until the error is corrected, *i.e.* the automatic reset causes an apparent increase in controller sensitivity until no further corrective action is required.

The effect on valve stem velocity is reduced as the set point is approached, and this tends to minimise or even eliminate oscillation or hunting.

How it works

An air-operated controller complete with automatic reset is arranged similarly to that in Fig. 2, but a second bellows has been mounted so that its motion opposes the proportional response bellows. If a flow change occurred because of a change in supply tank level, the first response would result from a change in separation distance between the baffle and nozzle and cause the control valve to open. But air starts to flow from one bellows to the other, at a rate dependent both on the reset valve and the pressure difference between the two bellows. This restores the nozzle to its original position. Because of this secondary adjustment of the distance between the nozzle and baffle, the valve is re-positioned until the flow assumes its set rate. Automatic reset action ceases when the two bellows are at the same pressure.

For any setting of the reset valve between the bellows, the flow of air through it depends on the pressure difference across it. This pressure difference is proportional to the deviation from set point and to sensitivity. The reset rate, in terms of valve stem velocity, therefore, is increased in the same proportions.

Units with reset rate calibrated in valve stem velocity, or its equivalent p.s.i. per second, are not available because this will depend on user requirements. Instead, reset rate is simply expressed as the number of times per minute the pressure difference between the two bellows is being permitted to equalise. For example, if the pressure difference were 4 p.s.i. and were reduced to 2 p.s.i. in one minute, the reset rate would be $\frac{4-2}{4}$ or 0.5. The pressure difference is reduced at a rate of $\frac{1}{2}$ the original difference. If the reset needle valve were opened further, the initial pressure difference would drop faster in the same interval.

As was indicated earlier, automatic reset response produces an apparent temporary increase in sensitivity. Therefore, the actual sensitivity used will be less than that associated with proportional response. A good starting point for its determination is first to close the reset valve and then find the sensitivity which makes the pen describe uniform oscillations. These should be timed. The sensitivity setting should then be reduced to 45% of this value. Next the automatic reset valve should be opened until a reading of $\frac{1.2}{T}$ is obtained, where T is the cycle time of the oscillation.

Derivative action

In some applications, the point at which the variable is measured is distant from the point of control. In Fig. 6, a blending tank receives fluid from one fixed and one variable source. Some distance downstream is a specific gravity measuring unit. The controller attached to this equipment positions the control valve on one of the fluid inputs.

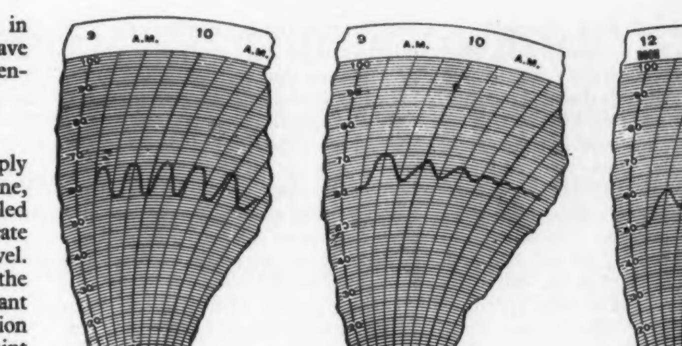


Fig. 4. Excessive sensitivity produces a steady oscillation, *i.e.* complete instability (*left*). As the sensitivity decreases, stability is eventually reached. Optimum conditions are shown on the right.

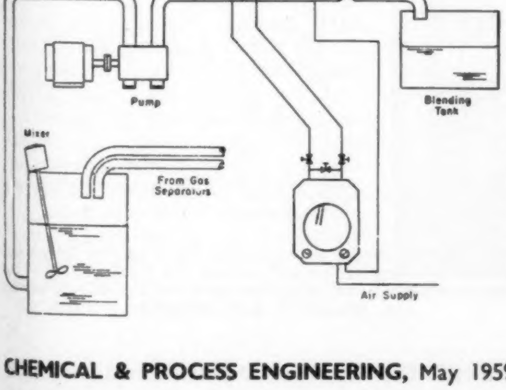


Fig. 5. In this system, flow rate will partly depend on tank level so that the set point would drift, unless automatic reset were provided by means of a second bellows, opposing the one in Fig. 2, and connected with it through a needle valve.

If the flow of fluid through the uncontrolled line should vary, the change in specific gravity would not be detected until after the new mixture reached the measuring element. The delay in detecting this change is a function of the flow rate and the distance between the blending tank and measuring tube. When the controller finally does go into action, its corrective effort may be too late and too small; nevertheless, it will continue to try to re-establish the specified gravity. If, later, the process fluid regains its correct gravity the controller again reacts too late, and continues to adjust the control valve.

Therefore, another control feature is required. Its function should be to add a definite amount of valve travel, the magnitude of which is exactly equal to the corrective action required for the time delay involved. If the fluid is travelling through the pipe at 2 ft./sec. and the point of measurement is 20 ft. away from the tank, a time interval of $\frac{20}{2}$ or 10 sec. is involved.

If a control function can now be added which responds to each change by moving the valve an additional amount to allow for this delay, then the controller will be up to date so far as its action is concerned.

This response is known as derivative and is obtained simply by adding a needle valve between the air relay and the proportional response bellows, as shown in Fig. 7. The follow-up action of the proportional response bellows is delayed and the controller output pressure exceeds the pressure in the follow-up bellows by the pressure drop across the needle valve. In other words, the control action is greater than that corresponding to the pressure in the follow-up bellows.

If the specific gravity is changing very slowly, the control pressure and the follow-up bellows pressure are very nearly equal. On the other hand, if the specific gravity changes rapidly, a much greater difference in pressure between these two points occurs. This is highly desirable for, if the gravity is changing rapidly, the valve should be adjusted even faster, by the time the controller senses the change, than if it were changing slowly.

Since the delay of controller action must determine the derivative response, the valve is calibrated in seconds and minutes.

For a controller with derivative action, the time setting on the little needle valve should be one-eighth of the steady oscillation cycle time. If the controller also has automatic reset, the sensitivity setting should be 60% of that required to cause steady oscillation.

Non-linearities

Flow and differential pressure bear a square root relationship so that sensitivity will vary also with total flow. This means that the controller sensitivity should be lowered as the flow control set point is raised. (This assumes the pressure actuating the diaphragm valve and actual flow have an approximately linear relationship).

If, for instance, the set point has been changed from 50 to 80% flow, sensitivity to flow change has then been increased by a factor of 1.62 and must be reduced accordingly. Each flow change also causes more corrective action at higher flow rates, and tends to increase the speed of oscillation. This means that a higher reset rate is needed. This will not be a proportional increase, however, and it is suggested that the rate be increased only 10 to 30% of the sensitivity ratio.

As indicated, this entire analysis of sensitivity correction is based on the assumption that the valve area and diaphragm pressure have an approximately straight line relationship. Bevel disc valves possess this characteristic over a flow range of 10 to 83%.

On the other hand, V-port, disc and throttle plug types fit in well if the controlled flow range is limited to 18 to 90% of maximum.

The ratio plug (also known as percentage type) valve has flow characteristics which require a relatively large increase in sensitivity as the controlled flow is reduced. In that case, the actual adjustment to sensitivity setting approximates twice the value determined by the above analysis. The reset rate would also require greater adjustment than that associated with the other three types.

Summary

In conclusion it can be said that the output pressure from an air-operated controller depends on deviation from set point coupled with the sensitivity setting; secondly, on the further adjustment required to prevent oscillations by automatic reset; and thirdly, on an additive effect, known as pre-act or derivative response, to compensate for delay between the actual change and its detection by the controller.

The sensitivity, reset rate and derivative response settings for most effective control were obtained from the Ziegler-Nichols paper on 'Optimum Settings for Automatic Controllers,' published in *Transactions of the A.S.M.E.*, 1942, **64** (8).

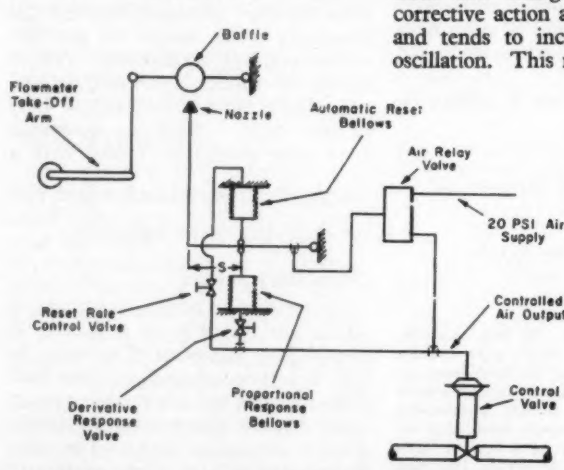


Fig. 6. Where a process lag is introduced between the measuring and control points, derivative action is required to allow for this.

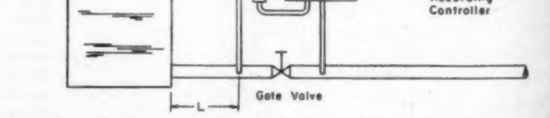


Fig. 7. With a needle valve in the input of the follow-up bellows, correcting action will exceed the feedback value by an amount varying with the pressure drop across this valve; and, therefore, with deviation.

Automatic Control in Industry

The three foregoing articles have given some indication of the techniques now available for automatic process control. To round off our special survey of this subject, we present below four examples of actual installations for the control of industrial processes, including the manufacture of cellulose, various chemical-manufacturing processes, paper stock preparation, and hydrogen production.

Centralised control at Austrian cellulose factory

Centralised control and supervision of the paper machine and its associated digesters, acid plant and pulp-washing plant has been achieved at a large Austrian cellulose factory by the use of two large illuminated circuit diagrams with control desks installed by Österreichische Brown Boveri-Werke, Vienna.

That for the digesters and acid plant contains the various indicators relating to these two sections, together with a large number of meters and recording instruments for supervision of the plant and the controls for remote operation of the pumps and valves. An alarm system with interlocks and follow-up circuits is also incorporated. Since space was very limited, only compact equipment could be employed.

The switchboard comprises three distinct sections: the top part is the illuminated diagram of the digesters and acid plant; the middle portion contains the various hydraulic and chemical instruments and recorders; while the lower part is the control desk.

Some 5.6 m. long and 1 m. high, the illuminated diagram has a dark background with transparent coloured lines indicating the passage of the pulp, steam, acid, etc., through the digesters. The pressure, temperature, content of the vessels and other readings important for the process are indicated by reflecting instruments, using a spot of light. In all, about 30 such readings are provided on the diagram. Auxiliary contacts in the contactors of the pump motors and small contactors actuated by limit contacts on the remote-controlled valves switch the lights on and off in those parts of the mimic diagram which portray the piping and thus provide a constant picture of the actual state of the plant.

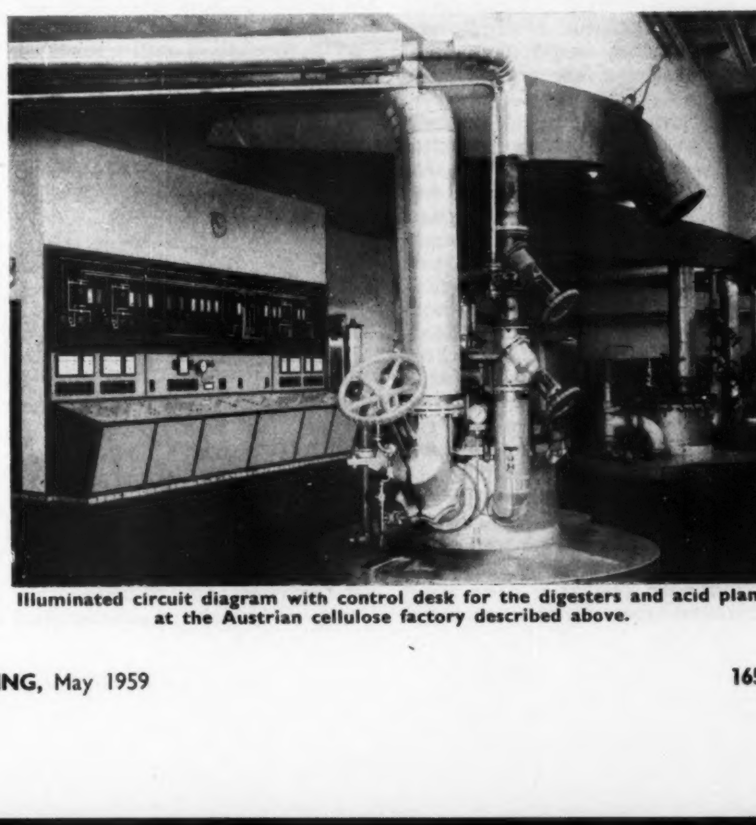
Under the glass panel is a sheet metal skirting containing two- and three-pen recorders, as well as certain hydraulic and chemical instruments.

Combined with the illuminated circuit diagram because of the limited space available, the hinged top of the control desk has a mimic diagram of the digester plant. In it there are about 80 miniature select and indicating switches for controlling pumps and valves. The 250 contactors, which control the pump motors, the hydraulic valve-operating system and the lighting for the illuminated diagram, are mounted with their plug-in bases on a rack at the rear of the panel.

When one of the pumps or valves is remote controlled, the element is selected by the corresponding switch on the desk, as a result of which a signal light flashes in the illuminated diagram. When the executive command is given to operate the chosen element, and on completion of the desired action, the indicator system acknowledges by changing the flashing light to a steady light with the aid of auxiliary contacts. Conversely, if an element breaks down, this is indicated by the flashing light accompanied by an alarm signal given by a horn.

A second, smaller illuminated diagram, 3.7 m. long, has been installed in the pulp-washing plant of the cellulose factory. It is used to supervise the operation of four blow tanks and a central lye plant. Basically, the construction and method of operation of this equipment is similar to that for the digesters and, since the washing plant follows the digesters, there must be a certain amount of coherence between the two as regards remote control and indication of the positions of the pumps and valves. Miniature select and indicating switches for 33 valves and 12 pumps are incorporated in this illuminated diagram. Eleven meter readings are available, while the duties of control and indication are performed by 140 contactors.

For transporting the chips from the chipper to the silos and from there to the digesters there is also a central control and indicating system housed in an enclosed cubicle. The entire route of the material can be followed on a diagram with illuminated arrows. In addition to the contactors, relays and control switches, the cubicle also contains humidity meters and a recorder for the automatic weighing machine. The successive conveyor belts and screws, as well as the elevators, are mutually interlocked so as to prevent any congestion of material should one section break down.



Illuminated circuit diagram with control desk for the digesters and acid plant at the Austrian cellulose factory described above.

Modern instrumentation at German chemical works

Automatic control techniques have been applied to good effect in various production processes at the works of Chemische Werke Hüls A.G. at Recklinghausen, Germany. When the company ceased to be part of the J. G. Farbenindustrie group it embarked upon a programme of modernisation which embraces the production of acetylene, sulphuric acid, ethylene and other chemicals, and the introduction of centralised controls led to considerably increased production, efficiency and economy.

The 17 arc furnace units which produce acetylene from gaseous hydrocarbons may be regarded as the heart of the works at Hüls, and a number of these have been converted to automatic operation. Some 15 different functions are performed by the equipment accommodated in the plant's control panels; in the past these were attended to by hand. By using automatic control, faults are automatically eradicated and rates of flow, temperatures, amperages and voltages are maintained constant.

Another process at the Hüls works is concerned with the utilisation of the large quantities of residuary sulphuric acid which occur there. It is largely automatic in operation. The acid is converted to sulphur dioxide; this is scrubbed, filtered and dried and then led to a contact furnace where, together with air, catalytic conversion to sulphur trioxide takes place. This is processed to sulphuric acid by the conventional method. In this plant, the control station of which features a graphic panel, temperatures, pressures and rates of flow must be maintained at specific values.

The recovery of trichlorethylene from acetylene and chlorine is another operation to which central control techniques are applied to ensure that process variables are kept constant, while yet another is a tube furnace installation for converting ethane, propane, etc., to ethylene. The tube furnace control station is situated completely apart from the other installations, being connected with them only by electric cables and compressed-air pipes of the smallest diameter. Ethylene serves as raw material for the production of ethylene oxide and styrene for plastics manufacture.

At Hüls the production of hydrogen cyanide from methane and ammonia is combined with the production of acrylonitrile from acetylene and hydrogen cyanide, the entire plant being controlled from a single central control station. Owing to the complicated nature of the processes it was not found possible to incorporate the control and recording instruments in the graphic panel; instead, there is a system of lamps which light up in the case of trouble at particular points, while the temperature at a given point in the plant is ascertained with the aid of a telethermometer and telephone dial selector equipment.

Perhaps the most impressive use of automatic control at Hüls is that found in the plant for the manufacture of ethylene oxide, which is obtained from ethylene and air by the contact process. Altogether 35 different operations have to be automatically controlled and the plant has a total of 281 warning lights, while 186 recording instruments and 229 indicating instruments are accommodated in the central control station, from which the temperature can be measured at 250 different positions throughout the plant. Six electronic compensating recorders are located in a single control panel; within 48 sec. each of them records 12 different temperatures.

The more important off-normal conditions give rise to both audible and visual alarms within and on the panel. Acknowledgment of the alarm fault cancels the audible alarm and the previously flashing alarm light becomes steady until the fault is cleared.

Automatic control of paper stock preparation

The instrumentation and control of a stock preparation plant at the Reed Paper Group's Empire Mills Ltd. provides an example of the level of automatic control now attainable in this industry. The plant, which supplies paper stock at the desired consistency and composition to the machine wire, is illustrated schematically below.

The baled pulp is fed in batches by a conveyor (*A*) to a *Hydrapulper* (*B*), where it is agitated with water (*C*) and a china clay slurry (*D*) to form a rough stock. Starch and dyes are also added here. Batches of rough stock from the *Hydrapulper* are stored in a dump chest (*E*) in which an agitator is rotated to prevent stock de-watering. Any broke (*J*) is returned from the machine to this point. The rough stock is then mixed with a regulated quantity of water (*F*) through the medium of a consistency controller and, in this way, stock of the desired consistency passes forward to the *Hydrafiners* (*G*) whence, after initial de-fibring, it is pumped into the rough stock chest (*H*).

After leaving this rough chest (*H*) the stock is diluted with water by a second consistency controller.

Two large unrefined chests (*K*) provide a large capacity and ensure a steady supply of stock to the *Jordan* refiners before which bulk alum is added (*L*) from which the stock is transferred to the refined stock chest (*M*). The refined stock is then pumped to the machine headbox (*N*), and between the refined stock chest and the headbox the final consistency controller adds water to ensure that the stock leaving the plant is at the desired consistency.

A *p*H recorder-controller measures and controls the *p*H after the headbox, the alum solution control medium being admitted at the mixing pump inlet.

Each of the chests, with the exception of the dump and broke chests, is provided with level controllers which

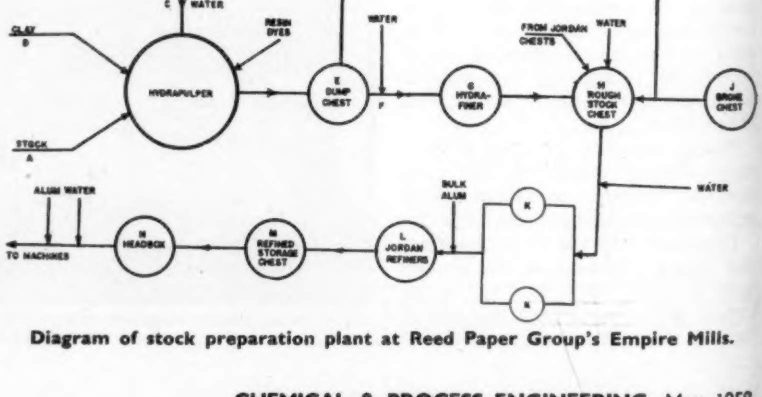


Diagram of stock preparation plant at Reed Paper Group's Empire Mills.

regulate the stock supply and, in addition, each chest has a low-level detector and a low-level alarm signal light. The low-level alarm is connected to a central alarm system and is also arranged to stop any outgoing pumps under this condition. Similarly, high level automatically stops stock input pumps. A further refinement ensures that stock plugging cannot occur, this being done by making the instrument system automatically shut any nearly-closed valve. This state of affairs is continued until such time as the relevant control valve is called, by the instrument circuit, to have a wider open position than a certain pre-set minimum opening.

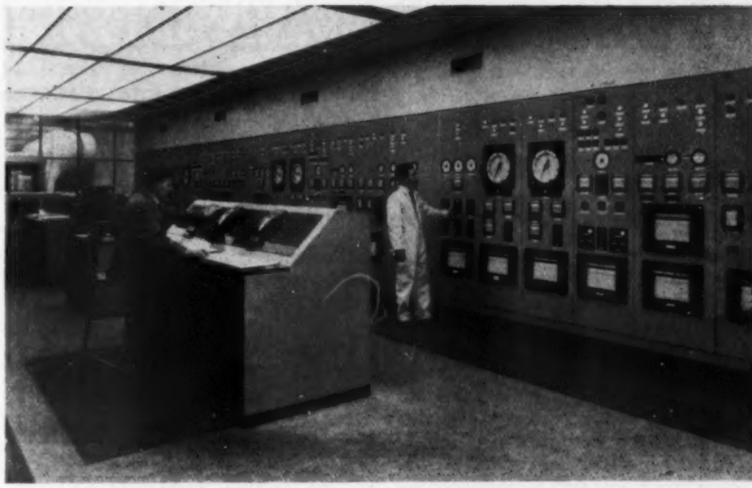
The *Hydrafiner* and refiner protection systems provide that on low flow, or stoppage of the stock supply pumps, the plugs are withdrawn immediately and the *Hydrafiners* and/or refiners shut down with the pump(s), if the pump(s) have not already stopped, after a pre-set time delay. The individual *Hydrafiners* and refiners have a low-pressure alarm protection device which withdraws the individually affected plug(s) immediately and stops the stock supply pump(s) after a suitable time delay. The usual 'inch-in,' 'inch-out,' 'run-out,' 'start,' 'stop' and 'reset' push buttons are provided for each *Hydrafiner* and refiner, the operation of which can be assessed from the kilo-watt recorders mounted on the control panel.

Automatic control of hydrogen production

A new, largely automatically controlled process for the large-scale production of hydrogen is utilised in the oil gasification plant which has recently been completed by Imperial Chemical Industries Ltd. at Billingham, Co. Durham. The plant is equipped to an unusually high degree with safety locks, alarms and signals. Over three miles of instrument impulse lines were installed, together with a further 18 miles of small-bore copper and 10 miles of multicore plastic tubing for pneumatic transmission.

The main control room, which is air-conditioned, houses two control panels, each 60 ft. in length, on which are mounted the flow, pressure and temperature instruments, together with the signal lights, safety locks and motor controls.

Continuous stream analysis and plant performance monitoring are carried out in three separate instrument rooms equipped with analytical instruments which include infra-red hydrogen sulphide analysers, oxygen analysers and a mass spectrometer for quality control. Many important temperatures are monitored continuously and automatically.



Control room of I.C.I.'s new oil gasification plant at Billingham.

Site erection of the extensive instrumentation and control equipment for the process was carried out by the automatic control division of Constructors John Brown Ltd. over a period of 18 months. At the peak of the installation work, some 200 skilled and semi-skilled men were employed on the instrumentation together with supervisory staff consisting of a site manager, three engineers and eight foremen. C.J.B. believe that this is the largest labour force of its kind ever to be used on an instrumentation contract in the U.K.

Atomic energy reshuffle in Britain

Changes in the organisation of the United Kingdom Atomic Energy Authority to be effective from July 1 have been announced.

Hitherto the Authority has been made up of three groups—research, weapons and industrial. The Industrial Group, which has become too large for convenient management, will now be divided into two, the Development and Engineering Group and the Production Group.

Sir William Cook, with the title of Member for Development and Engineering, will be executive head of the Development and Engineering Group and will in addition retain corresponding functional responsibilities throughout the Authority.

Sir Leonard Owen will have the title of Member for Production (Designate) and will be the executive head of the Production Group.

Sir William Penney, already appointed to succeed Sir John Cockcroft as the Member for Scientific Research, will in addition become the executive head of the Research Group, while retaining his functional responsibilities for scientific research throughout the Authority.

The Development and Engineering Group will be responsible for the development, design and construction of reactors and associated plants (with the exception of certain development work which will continue to be undertaken by the Research Group); engineering consultant work for the Electricity Boards, overseas organisations and the industrial consortia, and for the general engineering design and construction of all major building projects. This group will include headquarters staff at Risley, Lancashire; the Dounreay Experimental Reactor Establishment, Caithness; the Culcheth Laboratories, Lancashire; and research and development organisations at Capenhurst, Windscale and Springfields.

The Production Group will be responsible for the operation of the Authority factories (including the Calder Hall and Chapelcross reactors); research and development in aid of factory processes; and commercial activities of the existing Industrial Power Branch. This group will include headquarters staff at Risley and plants at Capenhurst, Springfields, Windscale, Calder and Chapelcross.

FRACTIONAL DISTILLATION

By H. H. M. Jones, B.Sc., A.M.I.Chem.E.

PART 1—*Developments in batch, azeotropic and extractive distillation; perforated and bubble-cap plates; wetted-wall and packed columns.*

THE following review covers approximately a two-year period and to limit its length on this occasion it has been decided to omit references to vapour/liquid equilibrium data. These, although indispensable in the solution of a particular problem, are not perhaps of general design interest. For the latter reason, reports of purely laboratory investigations and design of the relevant apparatus are not included. It is hoped that what remains will be of concern to the practising chemical engineer.

Batch rectification

In two papers Tsyuĭ-Fu[1, 2] develops a theory for the batch fractionation of ideal binary mixtures. An approximate equation is given showing the relationship between the reflux ratio and the kettle composition. It is based on the assumption of a constant quantity of vapour at any point in the column. The above relation on modification can be used for constant values of reflux ratio or for constant product composition, and the time cycle for a batch with constant reflux ratio can also be calculated. It is thought that the method, though less accurate, requires fewer plates than those resulting from a graphical method. Such a method is combined with a numerical one by Billet[3] to determine the transient rectifying conditions in a batch distillation when constant product composition is assumed. These transient conditions are expressed as a function of time and an example is given. The use of steam in the separation of multi-component mixtures by batch distillation is investigated by Holland and Welch,[4] who arrive at a new method of determining the steam requirement.

In an attempt to combine the advantages of sharpness of separation at total reflux with the recovery of a fractionated product, Kazuo Kojima[5, 6] suggests the insertion of an overflow vessel between the condenser and reflux return point. Its volume should be made variable to obtain a product of desired composition. A comparison is also made of the sharpness of separation using this method with a normal separation where regular finite reflux is used. The average distillate composition at nominal cut point is used as a basis of comparison in the case of the fractionation of methanol/water. The thermal requirements in batch distillation operations are considered by Stiehl and Weber[7] where regular hold-up and binary mixtures are considered. The additional variables imposed by a discontinuous process are taken into account and the two cases of (*a*) constant product and (*b*) constant reflux ratio are separately calculated.

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Azeotropic and extractive distillation

General methods of azeotropic and extractive distillation for the solution of difficult separation problems in the laboratory are described by Krell[8] who, in a general survey, prefers extractive to azeotropic distillation because of the unlimited number of compounds among which a choice can be made for a suitable extractant, since the latter does not have to form an azeotrope. A somewhat similar approach is made by Kogan[9] for the selection of suitable agents for extractive distillation. He states that the separation depends not only on the 'interaction intensity' of the added substance with a component of the mixture but also on a lower mutual interaction intensity of the components of the mixture itself because of the dilution with an external agent. Approximate equations are derived for the evaluation of extraction efficiency in binary systems based on vapour/liquid equilibrium data for the three-component systems possible.

In the design of azeotropic fractionating columns Ellis and Pearce[10] review the methods which have been suggested for the specific system acetic acid/water/ethyl acetate. They state that tray-to-tray calculations are accurate but tedious because of the small plate-to-plate changes in concentration which occur in acetic acid in the rectifying section. One method favoured is to start from the reboiler and use tray-to-tray analysis to a point just above the feed plate, from whereon the concentrations of water and ethyl acetate are relatively constant and to complete the calculation with a log/log plot for acetic acid.

The difficult problem of rectification in a ternary system with an azeotrope of the 'saddlepoint' type is treated by Bushmakin and Kish.[11] Such a system is represented by methyl acetate/chloroform/methanol. It was found that the causes of the variable composition fraction associated with a falling boiling point were a characteristic of the system and could not be avoided even in an ideal column.[12] A graphical analysis led to this conclusion. Previously Reinders *et al.*[13] had shown that such a variable composition fraction could be present without a saddlepoint-type azeotrope and the authors give the example of acetone/chloroform/benzene ternary.

Two practical problems of fractionation which concern azeotropic distillation are the separation of mixtures of butyl alcohol and butyl acetate, which Gel'perin and Novikova[14] show can best be solved by a rectification apparatus consisting of two columns working at different pressures for the separation of two azeotropic mixtures with minimum boiling point, and the recovery of acetic acid which Othmer[15] reviews.

Perforated plates

A discussion of the methods of calculation for perforated-type distillation trays is given by Eduljee.[16] Account is taken of factors such as the number and size of holes, minimum vapour rates, froth height, pressure drop through the plates, and plate efficiency. A sample design is worked out for a specific duty.

Another procedure is laid down by Chen-Jung-Huang and Hodson[17] which is suitable for both manual and computer calculation and is based

systematically on all the factors affecting performance, including tray deflection and levelness. The effect of the latter on the mass transfer between vapour and liquid on sieve plates is studied by Kuzminykh and Rodinov.[18]

A more detailed study of the efficiency of a sieve plate column and the pressure drop across it, taking into account the effect of plate thickness, is investigated for three specific systems by Jones and Van Winkle.[19] It was found that, in a laboratory column of 3 in. diam. and at very high throughput, the efficiency was the same for all plate thicknesses and that the pressure drop is slightly less as the thickness increases. Curves of efficiency and pressure drop versus gas velocity show discontinuity at the same point as the gas velocity is decreased. A more detailed investigation was carried out by Umholtz and Van Winkle[20] into the variables in a perforated plate column which affect column efficiency and pressure drop. They examine specifically the effect of free hole area, hole diameter, hole spacing, weir height and downcomer area. The one system octane/toluene was used, but the reboiler composition varied from one set of experiments to another. The results show that, for the same throughput, the overall plate efficiency was the same for the free areas tested (from 2.3 to 16.2%), approximately the same for various hole diameters, slightly more with increased hole spacing and with increase in weir height and less with increase in downcomer area.

The sizing of a sieve tower as a function of the permissible pressure drop is the subject of a method developed by Teller[21] in which he defines 'active tower area' as the area of the plate that contains perforations, not the downcomer area, etc. The method is based on an active area requirement as a function of permissible pressure drop and on a graphical relation of tower diameter to active area.

A feature of a perforated plate is the violent mixing of vapour and liquid above the plate and this matter has been investigated by two teams of workers. Firstly, Johnson and Marangozis[22] attempt to establish the relationship between plate and point efficiencies in a sieve tray where liquid splashing is considered as a new mechanism for mixing the liquid phase in the direction of flow. Splashing measurements are correlated with flow rates, weir heights, kinematic viscosity of liquid and aspects of tray geometry. A different view is discussed by Aksel'rod and Yusova[23] who, as a result of air/water experiments, come to a conclusion that a depth of water greater than 5 mm. does not affect dispersion of droplets and that their size distribution persisted. Mass transfer occurred primarily at the emulsification layer.

The practical application of a sieve plate problem was described by Aerov *et al.*[24] in the rectification of the ternary mixture ethanol/methanol/water. The calculated concentration on each plate was obtained by a graphical analysis and these agreed with experimental values. The concentration of the intermediate component (ethanol) is at a maximum approximately at the feed plate, where a calculated value was given as 20.2% compared with a measured value of 16.8%.

Correlations developed by Hughwerk and O'Connell[25] enable an accurate prediction to be made of the dry and wet pressure drop across a perforated plate, the hydraulic gradient and the stability. Rush and Stirba[26] measured plate efficiency for various binary separations and found that the resistance to mass transfer was in liquid or gas phase depending on the mixture.

Bubble-cap plates

Simple methods for calculating the variables in a bubble-cap plate are given by Molesworth[27] and a somewhat similar survey of the characteristics of columns in which liquids and vapours are brought into contact with bubbling is made by Kölbel and Siemes.[28] On the other hand, Kirschbaum[29] has surveyed a large amount of data on the computation of such plates and has correlated the result by an equation from which the diameter of a plate can be calculated in terms of bubble-cap diameter, plate spacing and densities of liquid and vapour in contact. The advantages and disadvantages of various constructional methods for bubble-cap columns are discussed by Robin,[30] who favours the sectional tray because of its better ability to cope with thermal expansion, although having a higher leak potential. Another mechanical detail of the bubble-cap plate is the slot shape itself and it is shown by Chernyavskii[31] that a T-shape is best able to cope with the non-level installation of the plate.

A relationship for the mass transfer between liquid and vapour on bubble-cap plates is examined by Bol'shakov[32] who presents a dimensionless relationship involving Nu, Re and Pr, together with the width of the slot and the effective height of the bubbling layer. Constants appearing in the equation have been determined from experimental results and from data available in the literature. It is shown that the principal resistance is in the gas phase.

A simplified relationship for Murphree efficiency in bubble-cap columns during the rectification of binary mixtures is developed by Ogawa,[33] who relates point efficiency to the overall efficiency. The formula derived is similar to that evolved by Gautreau and O'Connell.[34] The formula takes into account the various physical dimensions of the plate and the bubble caps.

Another important factor in the practical application of bubble caps is the entrainment between one plate and another. Eduljee[35] discusses the various factors involved in this phenomenon and suggests that in design calculations the vapour velocity should first be determined which gives the highest efficiency, *i.e.* that which ensures that the slots of the caps are fully utilised. The calculation should then be carried on to determine the plate spacing which gives a predetermined amount of entrainment at this vapour velocity. An example illustrates the method. Another factor of importance in a bubble-cap column is the drainage time and the relationship developed by Lockhart[36] enables this to be determined.

Manning *et al.*[37] claim that mathematics have not yet explained adequately the interchange between liquid and vapour in a bubble-cap column. They say that for good large-scale design a large-scale experiment is necessary, and describe a column 5 ft. in diameter, 30 ft. high.

Wetted-wall columns

The hydraulics of a wetted-wall column under conditions of laminar liquid flow are investigated by Michalik[38] using the classical hydrodynamic approach, and flow profiles are developed. Fastovskii and Petrovskii,[39] on the other hand, studied the operation of a wetted-wall column in turbulent flow region under conditions of infinite reflux ratio. They found that the principal resistance to mass transfer in a film of this type was in the vapour phase and the liquid resistance can, for practical purposes, be neglected; hydrodynamic analogy can be applied to a film rectifier and used for the design of such an apparatus. The fundamentals of mass transfer into such a column were also examined by Nikolaev,[40] who determined the mass transfer coefficient over a wide range of conditions covering both turbulent and laminar flow, and for various

diameters and heights of column. The experimental data were expressed as a dimensionless relationship of Nu, Pr and Re. He found that, with a spiral arrangement at the vapour entrance to the column, this mass transfer coefficient could be increased two to three times at certain vapour velocities.

The characteristics of rotating concentric tube columns in which the mass transfer to a thin liquid film is aided mechanically were examined by several workers. Hawkins[41] showed the relationship between such variables as throughput, pressure drop, equivalent theoretical plates, and hold-up. Rousseau[42] described a similar column for the separation of cis- and trans-decalin. This column had very small hold-up of 1.3 ml. and was the equivalent of 33 theoretical plates. The effect of the speed of rotation of the internal concentric tube was observed by Mair *et al.*,[43] who tested a distillation column previously described by Willingham *et al.*[44] at speeds up to 4,000 r.p.m. and having an annular space of 0.0465 in. It was noted that at speeds above 2,500 r.p.m. the separation was less than would be expected from the turbulence created, because of the generation of heat by friction in the vapour phase.

A further variation on the theme of a forced turbulent thin-film column is the introduction of wipers which serve to increase the turbulence in the liquid film and, at the same time, to redistribute it. Such a process is subjected to a theoretical interpretation by Billet[45] and a comprehensive numerical example for a benzene/toluene mixture is investigated. A further method to increase the turbulence and to maintain even distribution of the liquid film is the use of brushes and the construction and performance of such a device is described by Perry and Cox[46] and by Perry.[47] In this case, the still consists of a wire brush wound helically round a hollow shaft; the latter is cooled and the column is heated externally. The still can be operated without a head reflux. The separating power was shown to decrease with an increase in the liquor flow. It is claimed that this type of still would be very useful for high molecular weight separations because of the absence of any hydrostatic head.

A variation in this type of construction is the utilisation of parallel vertical surfaces, and Bancroft and Rae[48] describe a device of closely spaced parallel sheets of aluminium, these being arranged in sets 2 ft. high and the column consisting of such sets arranged alternately at right-angles to reduce channelling. This apparatus was found to have its best efficiency in the separation of water and deuterium oxide where H.T.U. values of 4.5 ft. and a pressure drop of 0.06 in. of water/ft. were observed.

The use of a wetted-wall column on a specific separation problem is described by Qureshi and Smith,[49] who found that, with binary and ternary mixtures and at infinite reflux ratio, the H.T.U. depended on the mixture being treated. For binary mixtures a simple function substantially independent of the concentration of each mixture has been devised which predicts the performance of the column. In the case of ternary mixtures, the H.T.U. for each component is found to be different, but in practice it is possible to use performance measured for binaries for the prediction of the separation of ternaries in the same column.

In the field of novelty, there is the column described by Atkeson[50] which consists essentially of a helical copper tube wound on a brass cylinder. Arrangements are made to cool the helix from the cylinder and to heat it on the external side. Partial condensation of the vapour on the cold surface of the coil and evaporation from the condensate on the hotter surface provide continual countercurrent contacting action. High vapour rates, low pressure drop and H.E.T.P. are claimed.

Packed columns

General reviews of the characteristics and performance of packed columns are provided by Ellis and Varjavandi[51] and Kafarov and Trofimov.[52, 53] Granville[54] presents a method of estimating the H.E.T.P. values for the separation of binary mixtures. His relationship refers to performance at loading velocity and with Raschig rings.

The equation includes the average slope of the vapour/liquid equilibrium curve, the reciprocal of the slope of the operating line and the packing diameter. It is demonstrated that the efficiency of a packed column depends, among other things, on the relative slope of the equilibrium curve and the operating line, the boil-up rate, the degree of wetting and of the physical properties of the binary mixture.

In two papers Kirschbaum[55, 56] describes experiments to determine the efficiency of two packed columns operating on an ethanol/water mixture. Comparing the results obtained with these two columns showed that the wall effects lead to a serious loss in efficiency because of the different arrangement of the rings in this area. To compensate for this irregularity, a wall of corrugated section was suggested which will allow for a higher vapour velocity without sacrifice of efficiency. The same disadvantage is discussed by Mullin[57] as leading to a maldistribution of liquid reflux over the column packing. The use of wire distribution screens designed by Manning and Cannon[58] and placed at 3-ft. intervals throughout the column has been shown by these workers to increase the fractionating efficiency by limiting the phase channelling.

The practical application of packed columns is limited by the flooding velocity and the available data on this factor are correlated by Kafarov and Dyknerskii,[59] who present an equation valid for columns from 30 to 2,000 mm. in diam. and for rings from 5 to 80 mm. It is claimed that calculated and experimental values agreed to within $\pm 12\%$. To cover the case of packed columns operating under vacuum, Sawistowski[60] presents a general graphical correlation based on the work of Lobo *et al.*[61] where the flooding rate is expressed as an empirical equation which on differentiation shows that the flooding starts at the top of the column, where the gas density is lowest.

Another factor of importance in considering the performance of a packed column is the wetted area of the packing. Hikita and Kataoha[62] present measurements made with Raschig rings of 25 and 35 mm. diam., according to the method of Mayo.[63] It was shown that the gas rate up to the flooding point and liquid viscosity over a reasonable range had no effect on the wetted area. The influence of other factors, such as liquid rate, surface tension and the packing diameter, were then expressed by a simple correlation shown by experiment to be correct to within 10%.

The influence of the surface layer of the packing itself on the separation activity of a packed rectifying column was investigated by Wolf and Günther[64] who found that, for the three binary mixtures heptane/methylcyclohexane, benzene/ethylene dichloride and ethanol/methanol, the separating efficiency was optimal depending on the plating of the rings with nickel or copper.

Columns having a new and higher efficiency packing material were described by various workers. Grein[65] described wire mesh of 3,600 mesh/sq.cm. and of 2 mm. coils. Eckert *et al.*[66] compared Pall rings with

Raschig rings and showed that the former have improved mass transfer coefficients and reduced pressure drop. These qualities they attributed to the increased utilisation of the inside surface of the ring and to a decreased tendency to channel. The Goodloe packing is described by Bragg.[67] This consists essentially of a flattened tube which is then crimped, the creases of the crimping being about 60° to the centreline of the ribbon. The tubes themselves are made of loops knit from strands of *Monel* wire. These ribbons are assembled so that the crimps cross one another and are then rolled together to form a cartridge of the required diameter. Tests with various diameters and heights show that such a packing compares very favourably with others also exhibiting a high efficiency.

An industrial-size precision distillation column is described by Kuhn[68] including the effect of operating variables and he gives several examples of the separation of narrow boiling mixtures in an apparatus previously discussed.[69] This device is a series of vertical multiple tubes which may be either open or filled with packing.

The practical use of Stedman's lens-shaped elements[70] is described by Zielinski,[71] who gives a simple method for manufacturing and charging a column with this packing.

The effect on the performance of packed towers in the presence of foam is investigated by Horwich,[72] who experimented with the stripping of H_2S from viscose rayon spin acid in the presence of a surface-active agent, the idea being to determine the main effects of low surface tension on gas/liquid contacting in towers. For this application rings were not satisfactory and a grid packing was used. The main result of the experiment was a large reduction in the capacity of the tower and a decrease in the rate of mass transfer resulting from a reduction in the effective gas/liquid contact area. Szadkowski[73] investigated the optimum working conditions in a packed column in the separation of several binary mixtures. He made extensive observation of the liquid behaviour inside the column and found that the best rectification was obtained when the column was filled with emulsified liquid. As the evaporation rate rises, frothing appears and later occupies most of the column. Just before the column reaches its maximum of equivalent theoretical plates, the pressure drop increases by about four times and the retention period in the column about five times.

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Part 2 of this article will deal with the mathematical design of fractionating columns, and with other miscellaneous aspects of fractional distillation.

Sulphuric acid in Holland

The Cyprus Mines Corporation of Los Angeles and the Albatros Sulphuric Works of Utrecht are to build a new sulphuric acid plant at Pernis, near Rotterdam, which will have a capacity of 120,000 tons of concentrated acid using pyrites from Cyprus as raw material. The four existing plants of the Albatros concern have a combined capacity of 150,000 tons. A new company will be floated.

FUEL FOR ATOMIC POWER

Chemical Engineering Triumphs at Uranium Processing Factory

British atomic power at present depends entirely on uranium, and the Springfields (Lancashire) factory of the U.K.A.E.A. plays a key role in supplying fuel for reactor projects. Thanks to chemical engineering, the extraction and refining of uranium can now be carried out in more continuous, more efficient processes.

IN the 13 years since the Springfields uranium factory was first envisaged by the atomic energy planners (then under the Ministry of Supply) tremendous advances have been made in the techniques of extracting uranium from its ores and converting it to metal for reactor fuel. Seen against the background of the formidable difficulties that faced the designers of the original factory, who had only laboratory-scale information to go on, and who had to hurriedly convert a war-time defence factory to their needs, the new plants recently established at Springfields by the United Kingdom Atomic Energy Authority appear as a marvel of chemical-technological progress and engineering skill. These new plants were briefly described in our February issue (page 39); here they are discussed in further detail.

The Springfields factory, situated on a 218-acre site between Preston and Blackpool, takes uranium concentrate from the Commonwealth, mainly Canada, South Africa and Australia, and converts it to uranium metal for fuel-element production, and also to uranium hexafluoride for use in the gaseous-diffusion plant at Capenhurst. The new plants relate only to the production of uranium metal and not to the hexafluoride. The new features include:

★ Use of concentrate instead of pitchblende as the starting material.

★ Purification of uranium solution by solvent extraction using tributyl phosphate.

★ Magnesium is used as a reducing agent instead of calcium in reducing the tetrafluoride to metal.

★ A fluidised-bed method of treating uranyl nitrate to yield uranium tetrafluoride will be introduced soon.

Raw material handling

Uranium concentrate, in drums, is first delivered to the ore-storage area, the drums being taken by lift to the tipping area as required. Samples are taken on a special machine in which the drum is raised so that a probe tube takes samples from every level in the drum. The drum then passes to a totally enclosed chamber; by remote control the drum is tipped into a hopper and the concentrate then passes by a screw feeder into the dissolvers.

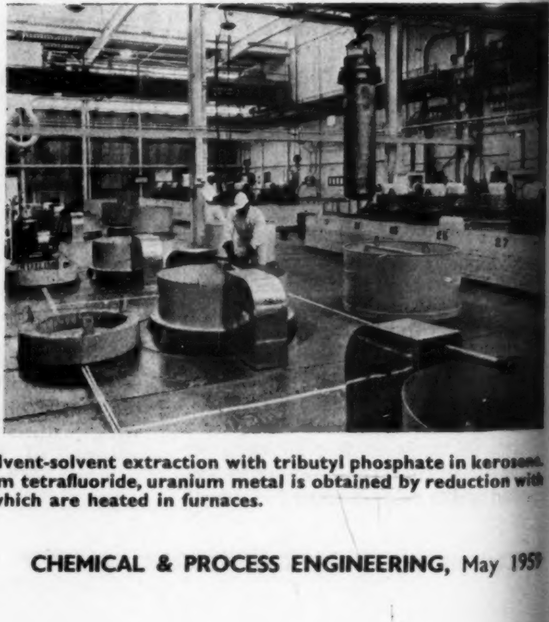
Four vessels in one

The dissolvers are large, stainless-steel tanks, divided by partitions into four compartments, each of which is fitted with a steam heating coil and an agitator. The crude material is dissolved in nitric acid in four cascading steps, all within the vessel which is effectively four vessels in one. The product from this stage, which contains some suspended matter, is filtered on one of four rotary precoat vacuum filters made in stainless steel. The filter cake is re-suspended, refiltered and then discarded while the filtrate passes to solvent-solvent extraction.

SEE FOLD-IN DIAGRAM FOR GUIDE TO URANIUM PROCESSES

Solvent extraction

This stage consists of solvent extraction with tributyl phosphate (TBP) in odourless kerosene in the cold, followed by extraction with hot nitric acid. The crude uranyl nitrate passes first into the tributyl phosphate phase and then is stripped back into nitric acid solution in a second plant. These operations are carried out in rectangular-box, mixer-settler units arranged in cascade.



Left: **After filtering the uranyl nitrate solution is purified by solvent-solvent extraction with tributyl phosphate in kerosene.** *Right:* **After the purified uranyl nitrate is converted into uranium tetrafluoride, uranium metal is obtained by reduction with magnesium in these reactors which are heated in furnaces.**

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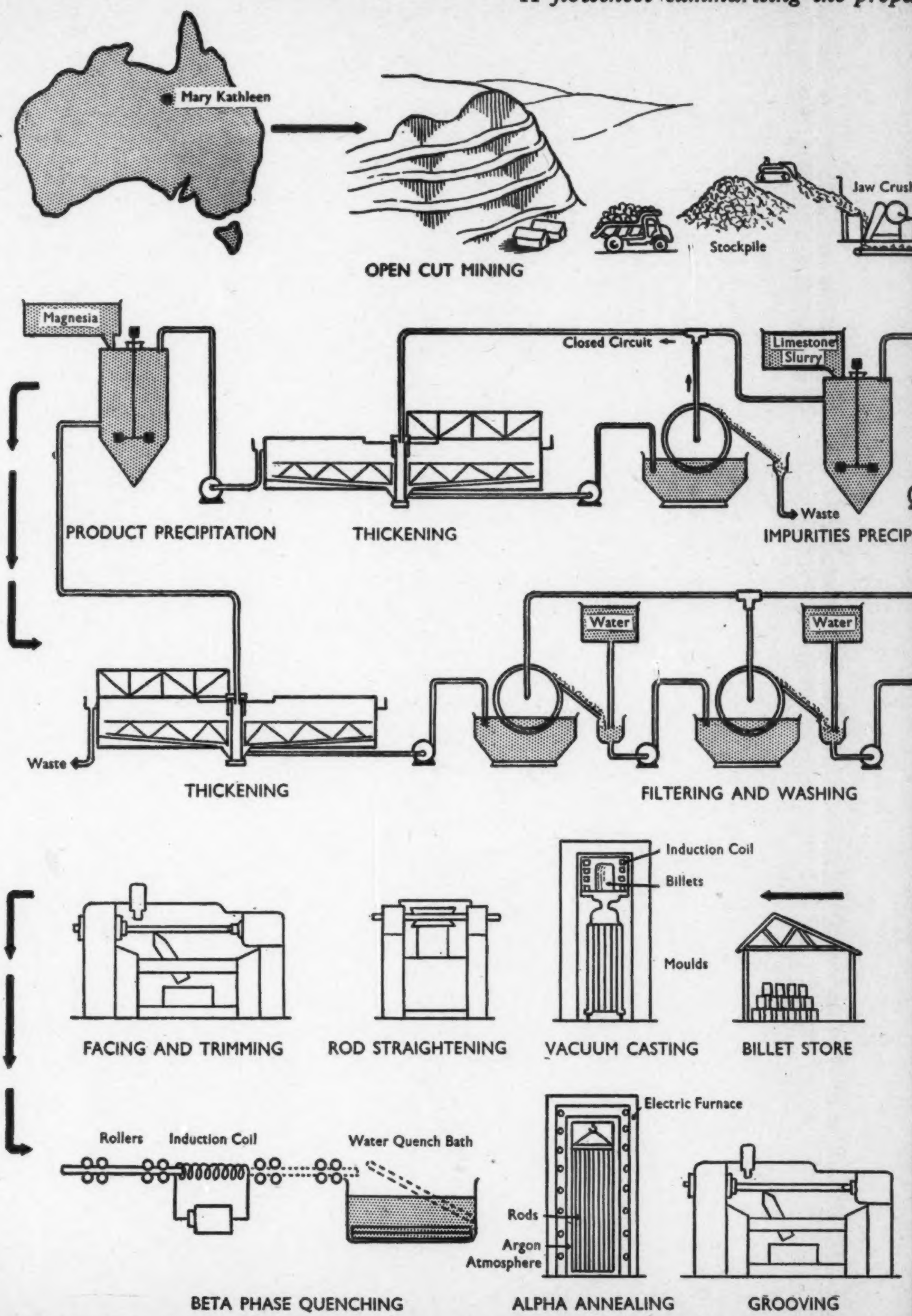
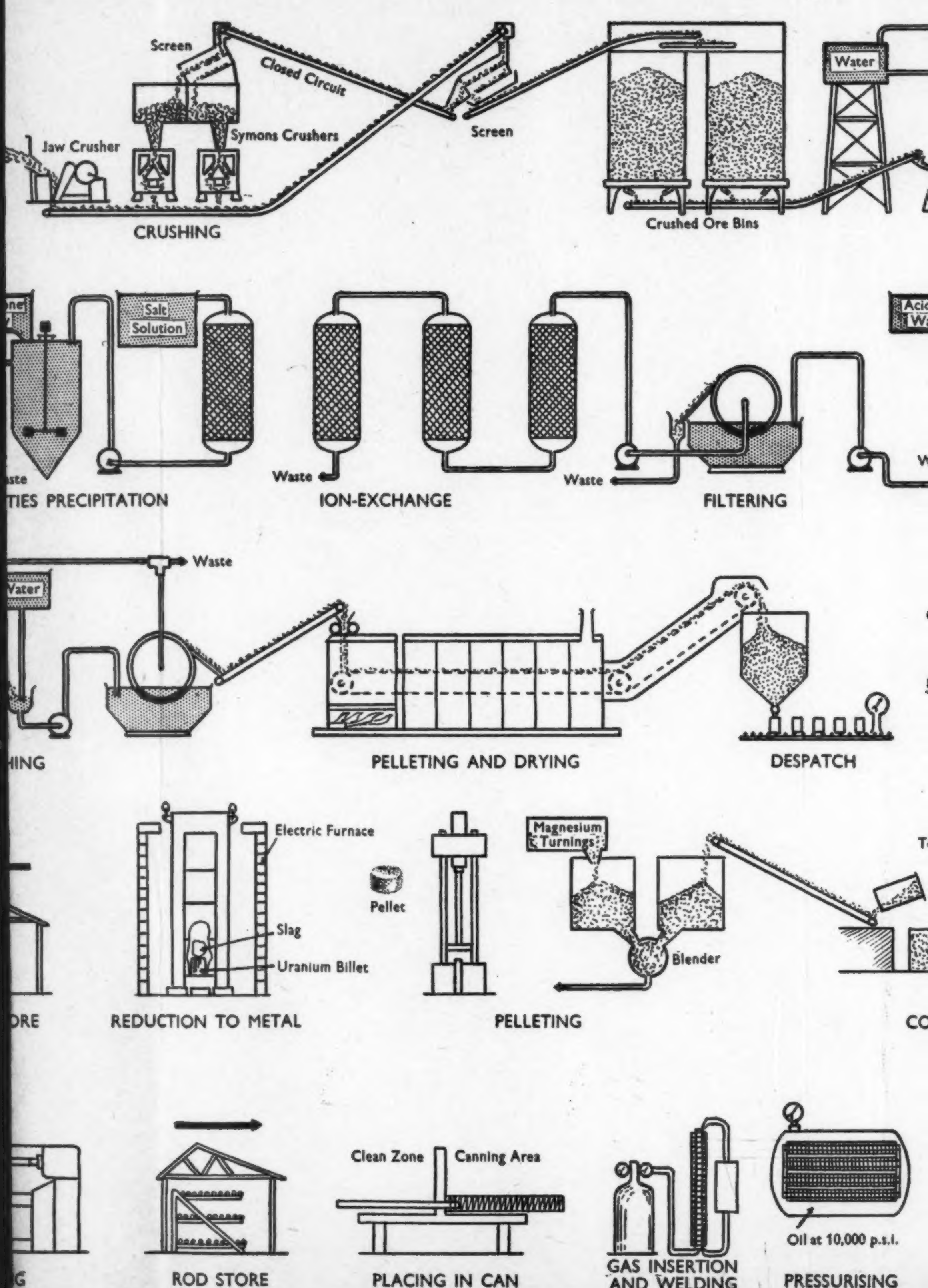


Processes in Uranium Production and Fuel Ele[...]

the preparation of "yellow cake" from ore in Australia and subsequent processing



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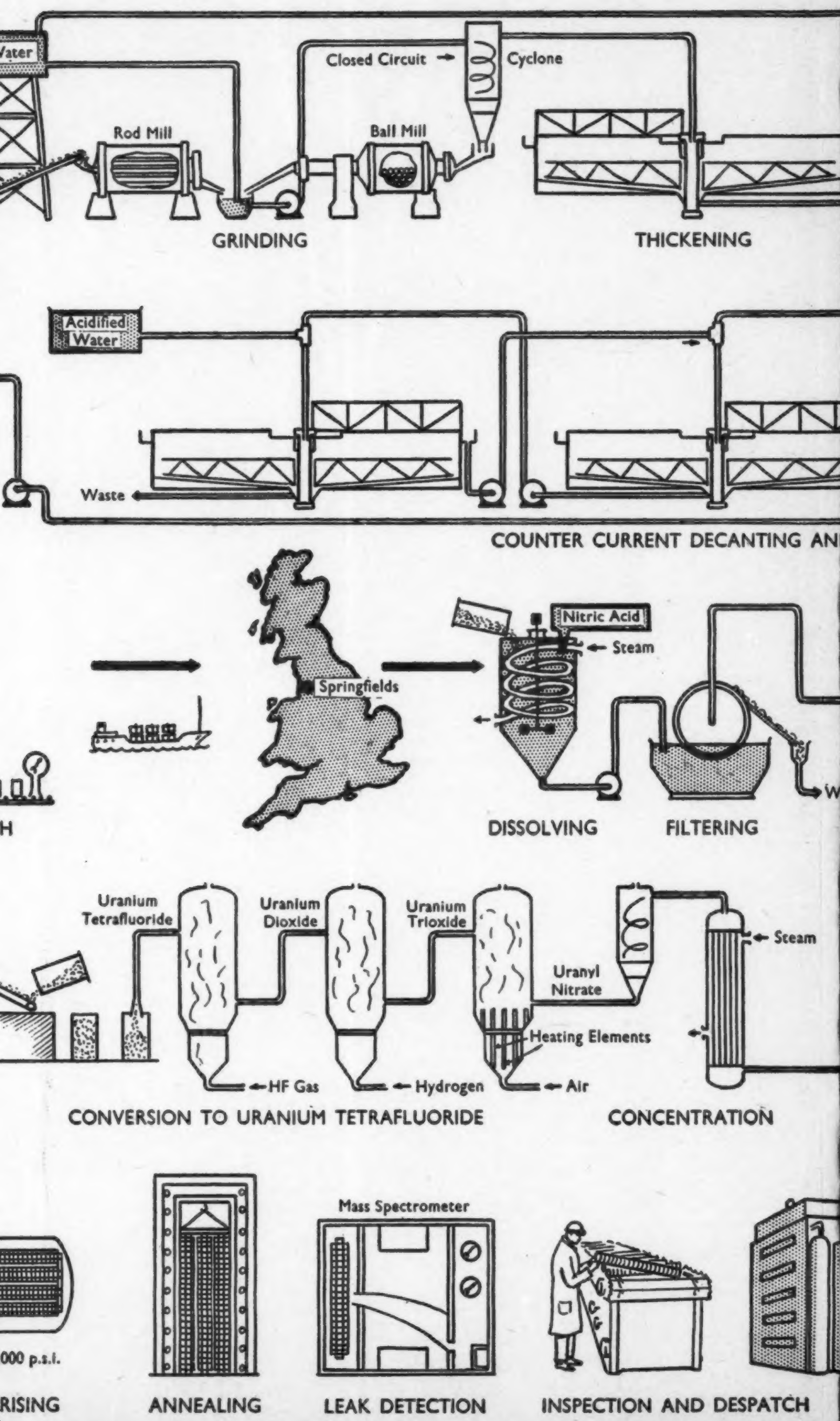

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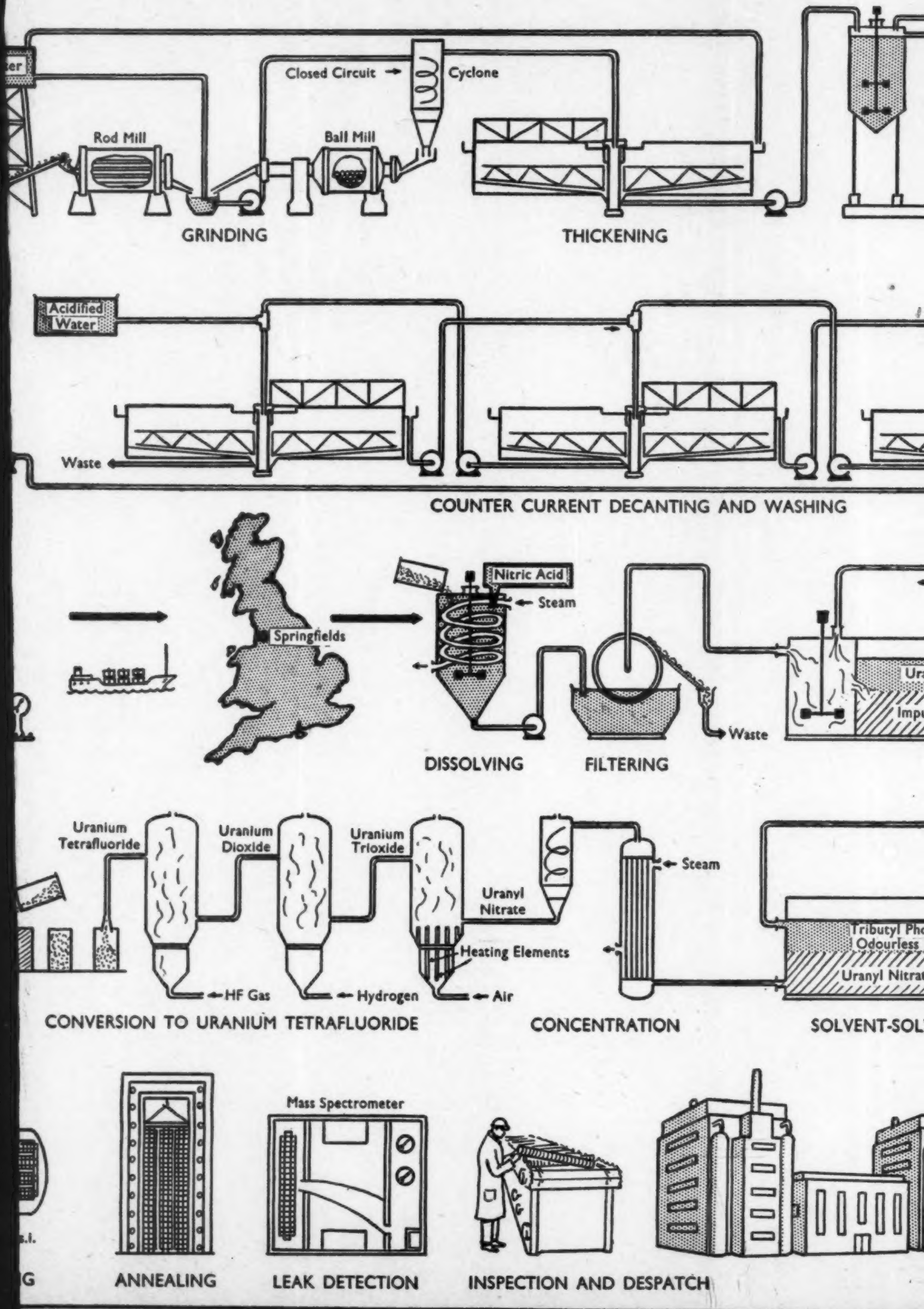
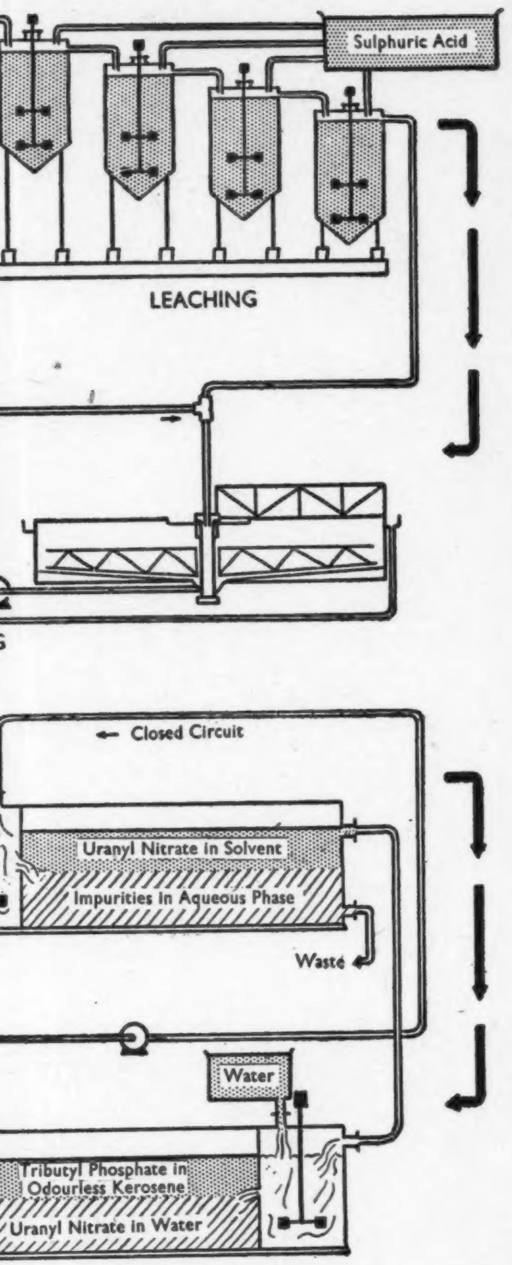
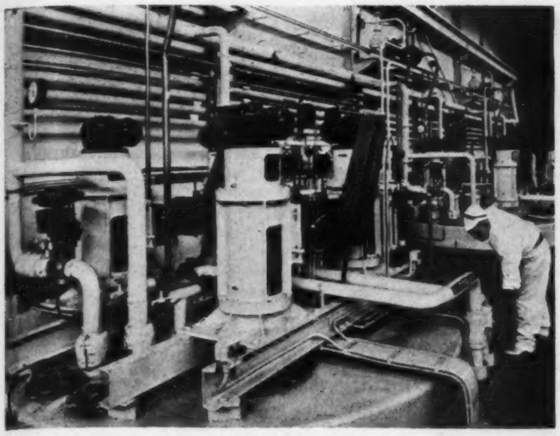
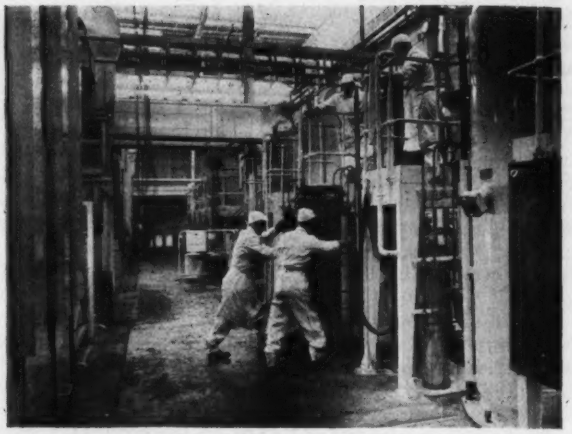




Supplement to

Chemical & Process Engineering





Left: **Concentrate from Australia is shipped to England and processed at the Springfields plant. The concentrate is first dissolved in nitric acid in these vessels.** *Right:* **Billets of pure uranium metal are first cast into approximate size for fuel elements. A charge of billets is melted in a vaccuum furnace working at ½ cm. Hg or less, and then run into moulds which can be charged as required. Here a set of 'Calder Hall' rod moulds are being fitted.**

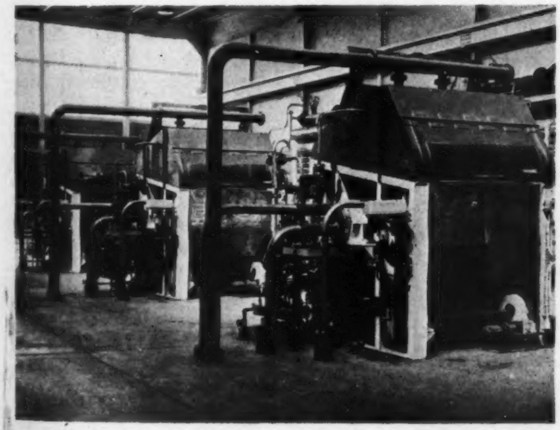
Each box consists of an agitated mixing section connected to a settling section where the phases divide. In 16 stages the separation is virtually complete and the solvent phase (TBP) flows up the plant while the acid phase, which is being stripped of nitrate, flows down and is discarded. In the second set of solvent extraction units, a purified uranyl nitrate solution is the product and the TBP, now stripped, is sent back for recovery.

Fluidised-bed development

Here the process at present reverts to the original. The uranyl nitrate solution is treated with ammonia to precipitate the uranium as ammonium diuranate, which is collected on Nutsch filters. This compound is then put through another older section of the Springfields factory to emerge as uranium tetrafluoride. Ultimately it is planned to carry out this part of the process by fluidised-bed methods and development work is at an advanced stage. The conversion to ammonium diuranate will be eliminated and in a series of three towers the uranyl nitrate will be converted to the tetrafluoride. In the first, the uranyl nitrate solution is sprayed into a tower up which is flowing hot, dry air; this converts each droplet of nitrate into uranium trioxide which as a solid becomes a fluidised particle. These pass over into the second tower in which hydrogen is the fluidising gas and this converts the trioxide to uranium dioxide. In the third tower, hydrofluoric acid (HF) is used as the fluidising gas to convert the dioxide to the tetrafluoride.

'Dryway' method

In the older method, ammonium diuranate taken from the Nutsch filters in the form of a thick yellow paste is loaded into circular trays of two types, one having a hole in the centre and the other a series of holes round the rim. The trays are stacked alternately in a container which is lowered into an electric furnace sunk into the floor and connections are made to gas lines and an effluent pipe. The furnace is first heated for some hours to decompose the ammonium diuranate, leaving uranium trioxide in the trays. Hydrogen is passed through, reducing the trioxide to dioxide, and then anhydrous



Material which will not dissolve in nitric acid is filtered out on these rotary precoat vacuum filters. The material removed is resuspended, filtered again and then discarded.

SIDELIGHTS ON SPRINGFIELDS

Faced with the urgent task of planning a uranium extraction and purification plant after the start of Britain's atomic energy project in 1946, the designers of the original plant found it impossible to do pilot-plant work, so they had to rely on test-tube data, including a new process to replace part of the original process developed by I.C.I.

The design organisation was completely new, it had no files or drawings to help it out and everything had to be designed from scratch. Product purity requirements made it necessary to consider levels of contamination measured in p.p.m. in handling materials used at the plant.

Above all, there was radioactivity to consider—this was the first U.K. factory in which radioactive material was to be handled by the ton and there was little previous experience to go on.

Whilst it is true that the change from pitchblende to concentrate as the starting material has eliminated the gamma radiation hazard due to radium and radon present as decay products in the ore, the progress made in plant design can be appreciated from the fact that no worker in the new plant has to wear a respirator or breathing apparatus in normal conditions. In fact, most wear simply overalls, boots and gloves.

The first drums of uranium ore were sampled in January 1948, less than two years after the formation of the organisation, and in the following October the first metal bars of uranium were produced from material which had passed completely through the works.

hydrofluoric acid which converts the dioxide to uranium tetrafluoride. The arrangement of the holes in the trays ensures that the gases effectively cover the whole of the material in each tray, flowing from the centre to the edges on one tray and in the reverse direction on the next. The three compounds produced during the process are markedly different in colour, thus providing swift and simple indication if the final conversion has not been completed.

When the process was originally being worked out, there were two alternatives for these stages, the other being carried out with solutions, and they became known as the *Dryway* and *Wetway* methods. In consequence, this part of the plant was always referred to as the *Dryway* section.

Magnesium reduction

Dry uranium tetrafluoride is thoroughly mixed with magnesium turnings and pelleted in a special press to give 3-kg. billets which are passed to the chemical reactor, erection and dismantling stage.

In this process for the conversion of the fluoride into uranium metal, the billets are stacked in graphite crucibles each some 28 in. diameter and 10 in. deep and these are stacked, in turn, in a chemical reactor vessel approximately 30 in. diam. and 10 ft. deep, made in stainless steel lined with graphite. A full chemical reactor is picked up by a crane and placed in a furnace bed. The vessel is purged of air, filled with argon at atmospheric pressure, and then fired.

Process details are still secret, but whereas in the old process, using calcium, the mixture did not require heating once the calcium was ignited, the magnesium mixture must be heated for most of the process, the reaction being exothermic, but the heat generated is insufficient to carry the reaction along. During this operation the temperature of the reactor and pressure inside it are carefully controlled. When the reaction is complete the vessel is lifted from the furnace bay into a cooling block for controlled cooling.

The chemical reactor vessel is then stripped and in each tray there is left a billet of uranium covered with slag. The billets are chipped out and passed down a conveyor to a cleaning section where baths of ammonium chloride and hot nitric acid solution remove all the adhering slag. After a final wet sand-blasting, the billets are stacked and taken to store.

Calculating Completeness of Mixing

To the Editor
DEAR SIR,

Referring to the paper 'Testing Dry Solids Mixers' by Dr. Bannister, which appears in your February 1959 issue, I would respectfully point out that the statistic which he advocates for expressing completeness of mix is of doubtful value, and may even be very misleading in certain cases.

I have for some time been concerned with the testing of farm food mixers which handle dry meals of varying particle size and have had to deal with this problem myself. I would agree with Dr. Bannister's sentence 'Most methods of testing the efficiency of dry solids mixers rely on statistical theory, the standard deviation or some modification of it being the favourite measure of dispersion used.' The formula for the standard deviation, however, should be:

$$\sigma = \sqrt{\frac{\Sigma (x-\bar{x})^2}{N-1}}$$

The state of the mix at a given mixing time t min. should be based upon the standard deviation of a number of samples all drawn at random from the mix at time t. This number of samples may vary from 5 to 20 or more.

As I see it, whatever index of completeness of mixing is used its value I_t at time t should not be influenced by the state of the mix at some earlier time(s) in the course of mixing. If calculated as I suggest, σ_t will in fact be independent of the state at times earlier than t. However, taking an example from Dr. Bannister's first table, Run 1, his value σ_9 is given as 38.3; unfortunately this *is* influenced by x_3 and x_6 in addition to x_9. The shape of Dr. Bannister's curves are misleading, therefore, and I expect that they should in fact be much flatter at the lower end.

There have been a number of attempts at deriving a suitable index, and to some extent the best index will be different for different tasks; in many cases it is useful to adjust the index with sample size. One example is given by P. M. C. Lacey, 'Developments in the Theory of Particle Mixing,' *J. Appl. Chem.*, 1954, **4** (5), 257.

I hope that these comments are of some value to you.

Yours faithfully,
P. HEBBLETHWAITE

13 *Cedar Close,*
Ampthill,
Beds.

Dr. Bannister comments as follows:

In theory Mr. Hebblethwaite is correct in using N − 1 *as his divisor, but where the number of samples is large clearly this correction is hardly material. It is, however, important to note that before taking the square root the smaller quantity must be subtracted from the larger in the numerator, since we cannot assume, as Mr. Hebblethwaite apparently does, that the mean* $\bar{x}$ *is always smaller than* x.

It is difficult to see what advantage is to be gained by using a mixing index which does not represent or is uninfluenced by all the stages in mixing. If mixing with a certain machine is imperfect it must be very difficult to ascertain the exact point on the time scale or in the length of a continuous machine where imperfection starts. Usually all parts of the machine and all periods of the mixing process contribute something to the misplacement of material. Although adding another source of variance the random method of sampling can be applied to batch mixers where the ingredients are accessible throughout mixing. In practice this is not always the case.

I would agree with the implication in Mr. Hebblethwaite's last paragraph that a better mixing index which is easier to apply would be of great benefit.

From billet to fuel element

Conversion of uranium metal to fuel elements is also undertaken at Springfields, the first step being to melt the billet in a vacuum furnace heated by a high-frequency induction billet and pour the molten metal into cylindrical moulds. After cooling, the rods undergo a succession of machining operations to bring them to the desired design, with heat treatments included.

Canning is the final big operation, a magnesium alloy known as *Magnox* being used for canning fuel elements for Calder Hall, Chapelcross and the new atomic power stations under construction.

After irradiation, the fuel elements are processed at the Windscale factory in Cumberland to separate the fission products and plutonium from the chemically unchanged uranium. This uranium, in which the proportion of the fissile 235 isotope is reduced, is returned to Springfields as a solution of uranyl nitrate; here it is converted to uranium hexafluoride for re-enrichment at Capenhurst.

Estimating Manufacturing Costs

FOR PROJECT EVALUATION

By J. E. Cran, B.A., B.Sc.

(Research and Development Department, The Distillers Co. Ltd.)

By concentrating on the more significant factors involved, such as capital, labour, maintenance, raw material costs, etc., the economic evaluation of a process can be simplified and a fair idea of manufacturing costs can be obtained. The author outlined the method at the Symposium on Chemical Engineering Economics, held by the Graduates' and Students' Section of the Institution of Chemical Engineers last October (summarised in CHEMICAL & PROCESS ENGINEERING, 1958, **39** (12), 437-441). *The following is based on this paper.*

IN process development work much time and effort is spent on economic evaluation of processes. Such enquiries are inspired in many ways. Enquiries pour in from the chemical laboratories, the market research department, the patents department and other quite unexpected sources. A process must be evaluated to justify further expenditure and this evaluation must be compared with similar evaluations for alternative, existing or competing processes. In the course of its development a process must be frequently re-evaluated in the light of new developments, both technical and commercial. This may be done a dozen times for a process which eventually becomes a commercial one. Fifty or even a hundred economic studies may be needed before a project can be found on which full-scale development work is justified.

To do this kind of work expeditiously we must dispense with unnecessary detail and, to preserve a basis of comparison, a standard procedure is more or less mandatory. It is also important that the quantities which are estimated are clearly defined and that the definitions are thoroughly understood by the engineer preparing the evaluation and the executive who has to give a decision on the basis of the evaluation. To procure these objectives a pro-forma is frequently used.

Fig. 1 shows a typical pro-forma used for compiling production or manufacturing cost estimates. This serves to standardise procedure and leaves little doubt in anyone's mind as to the significance of the various items used.

Capital

An estimated figure for capital is shown at the top. The time at which the estimate was made is also given so that allowance may be made for escalation when the estimate is reviewed at some future date.

A capital figure is needed because in calculating production cost an allowance must be made for depreciation and because the process is ultimately judged in terms of the return per cent. it will yield on the invested capital. The total fixed capital is shown as the sum of two items, installed plant and ancillaries. This is because different rates of depreciation may apply.

Since the amount allowed in the production cost is only a percentage of the capital and since it is not likely to be a major item, the capital at this stage need not be known with very great precision. It can be approximated by analogy with a similar process or by using a turn-over ratio. Familiarity with company policy and past experience adds value to assessments of this kind.

A flowsheet, however, and some chemical engineering design, will eventually be called for. This being so, it is as well to base the capital estimate on flowsheet considerations. The usual procedure is to prepare a flowsheet and from material and energy balances about each item determine, as well as available data will permit, the size of each item of equipment. The equipment items are then priced on the bases of size and materials of construction. Methods for relating total fixed capital to total equipment cost are well enough known. Briefly, the most common method is to multiply total equipment cost by a factor based on analyses of plant costs.

No provision has been made on the pro-forma for working capital. This could usefully be included, but is generally omitted from preliminary estimates which are prepared mainly for the purpose of comparing alternatives. The implied assumption is that working capital is independent of the nature of the route (or the product). This is by no means strictly true.

Utilities

These are materials used in the course of the operation which do not appear as such or as modifications or combinations in the finished products. Steam, power and cooling water are the main utilities required for chemical processing. Fuel is another and, no doubt, others may need to be entered under this heading from time to time.

To determine utilities requirements it is necessary to work from materials and energy balances around each item. In this way steam requirements for reboilers and heaters and water requirements for condensers may be determined with some precision. To the quantities so calculated must be added allowances for make-up of losses. On steam-heated equipment and in hot lines there will be some loss of heat by radiation. This must be made up with additional steam. Ten per cent. of the theoretical is usually more than enough to add against this loss.

Power is more commonly used for driving motors attached to pumps and compressors. The calculation of the theoretical work done on fluids by pumps and compressors is a straightforward operation. Because of losses of efficiency in the motor and in the pump the actual power required will be greater than the theoretical. The known efficiencies of pumps and motors can be used for this adjustment.

On the pro-forma the quantities of utilities, their unit costs and the total annual cost per ton are entered in the places provided. The unit costs of utilities are the costs at which these are available at the site. Steam, for example, will be supplied by a boiler house and, as the capital cost and raw materials in this unit do not appear elsewhere in the estimate, the

cost of steam must include raw materials, services, labour and depreciation charges involved in the production of the steam. Power may be brought from the electricity board and the price paid then covers the board's costs and profits. If the power is generated on the site it must be dealt with as outlined for steam.

Labour

The labour requirements will be of three kinds:

(1) Direct process labour.
(2) Day shift labour (yard gang).
(3) Supervision.

Direct process labour. This is the labour force necessary to carry out all the operations involved in running the process.

When making the first assessment it is unlikely that the chemical engineer will be in the position to carry out an elaborate analysis of labour requirements. Little thought will have been devoted to the precise details of control, either automatic or manual. At this point, therefore, the flowsheet is divided into a series of stages. For those stages which are likely to be critical or difficult, such as reactors or batch operations, one man is allowed; for the recovery operations such as distillation, absorption, extraction, filtration, etc., from $\frac{1}{4}$ to $\frac{1}{2}$ a man per unit is allowed. The flowsheet and some operating experience will provide the necessary clues.

For a continuous operation the labour requirements in whole numbers of men should be multiplied by four to allow for time off.

When the time comes to go into the labour requirements in greater detail pilot-plant data will have become available and problems of control will be better understood. All that may then be necessary is for judgment to be exercised in correcting the first estimate. On the other hand, one may go into greater detail with advantage from the flow sheet. A series of schedules is prepared for each item or each stage. Under each schedule should be written down each and every duty that must be performed—the reading of instruments, the loading or unloading of vessels, the checking of flows, steam traps and valves, the logging of instruments and so on. To each of these is allocated what seems an appropriate time allowance and to these sums are added reasonably generous allowances for spare time and for contingencies. Each sum in hours is divided by eight to determine the number of men required for each stage or item. However, it is important to remember that 'too many cooks spoil the broth,' and to make sure that each man has a clear responsibility.

Day shift labour. Additional men will be required during the day for general clean-up duties and for bagging of the day's production. These duties can be scheduled and compiled as for process labour.

Supervision. This includes foremen and shift supervisors. The cost of supervision on large undertakings where there are many processes and the supervisors' duties are spread over several is frequently estimated as one-third of the cost of direct labour. With an isolated process the cost of supervision must be given individual consideration in connection with the nature of the process and its labour force. In some cases a foreman may not be needed on each shift and in some cases both a foreman and supervisor may be needed.

The cost of labour can always be determined by reference to the payroll staff or by reference to official publications such as the *Ministry of Labour Gazette*.

Maintenance

The cost of materials and labour required for maintenance will depend upon both tangibles and intangibles. In the first place it will be clearly proportional to the amount of equipment to be maintained. For this reason it is usually estimated as from $2\frac{1}{2}$ to 10% of the total fixed capital.

From there on the variables affecting maintenance costs are difficult to assess. It can be seen, qualitatively, that a process handling corrosive materials may cost more for maintenance. High temperatures and high pressure may also add to maintenance costs. The original policies in procurement regarding specification and inspections will have to be considered as also will company policy with regard to maintenance. Policies can vary from those of carefully planned preventive maintenance to those which are quite haphazard.

What figure to select between $2\frac{1}{2}$% and 10% must be based largely on impression. Where they are available, cost accounting records will reveal the past history of maintenance costs.

Capital charges

These are also known as depreciation or amortisation charges.

In very simple terms these charges are amounts which are 'transferred' (in a book-keeping sense) to a savings account. The function of this savings account is to build up a sum of money equivalent to the original investment. Without capital or capital goods, industry ceases to exist, so it is a most sacred duty of industry to preserve and expand its capital. It has been argued that a capital facility such as a machine or process plant makes no real profit until it has paid for itself out of its own earnings.

What is to be regarded as the equivalent of the original investment is open to several different interpretations.

The first of these interpretations to consider is that of H.M. Commissioners of Tax. Under tax law only the exact sum invested can be recovered, through annual tax rebates in the form of depreciation allowances. A declining balance method is used in calculating these allowances. That is to say, each year's allowance is based on the written-down value of the asset at the beginning of the tax year. Thus, if the agreed rate is 10%, the allowances on £100 are £10 in the first year, £9 in the second, £8.1, £7.39, £6.65 and so on. Under this system, whatever the allowed rate may be, it will take an infinite number of years to recover the initial investment. The higher the rate the fewer years will be required to recover the major part of the investment. In addition to the annual allowance the tax authorities allow an initial allowance of 30% in the first year. Under this system, if the annual allowance is 10%, 10 + 30 = 40% of the investment is recovered in the first year and the remaining 60% in infinite years.

In actual practice the full amount does not have to be recovered by tax rebate. After a period of operation the plant will be obsolete or worn out, but it will still have value as scrap or as a second-hand facility.

If, for the sake of argument, this is assumed to be 20% and if the depreciation rate is 10% adjusted to 5/4 (10%) and the initial allowance is 30%, it will take nine years to recover 80% of the investment. The proceeds of the sale of the scrap at its written-down value will not be subject to tax. The percentages recovered are as follows:

Year	*Tax basis % recovered*
1	42.5
2	49.7
3	56.0
4	61.5
5	66.3
6	70.5
7	74.2
8	77.5
9	80.3

It is thus clear that by depreciation (tax-wise) and sale of scrap the original

FIG. 1. TYPICAL PRO-FORMA FOR COST ESTIMATE

COST OF PRODUCTION OF *X*

E/ /

Scale: *10,000* tons/annum

CAPITAL ESTIMATE (*2nd* quarter 1958)			ESTIMATED PRODUCTION COST	£ *·9 x + 35·5* per ton
Installed Plant	£ *400,000*		ESTIMATED SELLING PRICE	£ *·9 x + 55·5* per ton
Ancillaries	£ *200,000*			
TOTAL FIXED CAPITAL	£ *600,000*			

PRODUCTION COST			£/annum	£/ton
Utilities				
Steam	*200,000* tons @ £*0.5* /ton	*160,000*		
Power	*3,000,000* kWh @ *1.od.*/kWh	*12,500*		
Cooling water	*3 x 10⁹* Imp. gal. @ *3.od.*/10^3 gal.	*37,500*		
Process water	Imp. gal. @ d./10^3 gal.	-		
		210,000	*210,000*	*21.0*
Labour & Supervision				
Process labour	*20* men @ £ *600*/annum	*12,000*		
Supervision		*4,000*		
		16,000	*16,000*	*1.6*
Maintenance				
Materials and labour @ 5% on Total Fixed Capital			*30,000*	*3.0*
Capital Charges				
@ 10% on Installed Plant cost		*40,000*		
@ 5% on Ancillaries cost		*10,000*		
		50,000	*50,000*	*5.0*
Works Overheads				
@ 250% on Labour and Supervision			*40,000*	*4.0*
			346,000	*34.6*
Operating Cost				
Raw Materials				
Material A	*9000 tons @ £x/ton*	*9,000 x*		
Material B	*100 tons @ £100/ton*	*10,000*		
Material C	*200 tons @ 10/ton*	*2,000*		
		9000 x + 12000		*·9 x + 1.2*
GROSS PRODUCTION COST			*9000 x + 355000*	*·9 x + 35·8*
Credits				
Material D	*50 tons @ £300/ton*	*15,000*		
		9000 x — 3000		
NET PRODUCTION COST			*9000 x + 355000*	*·9 x + 35·5*
Return on Capital				
@ 33 1/3% on Total Fixed Capital			*200,000*	*20*
ESTIMATED SELLING PRICE			*9000 x + 555,000*	*·9 x + 55·5*

sum will be recovered in nine years.

If, however, 42½% of capital is charged as an operating expense in the first year few processes will appear attractive.

If the assumption of 20% scrap value is justifiable an annual provision of 10% of the original sum will reimburse 80% of the investment in eight years. This, over the eight years, has much the same result as tax allowances.

If the estimated life of the plant is less than eight years it will be necessary to make a higher capital charge. If, for example, the life is to be four years and the scrap value 20%, the appropriate flat rate will be 20% depreciation charge.

Another factor which should be considered is that the value of money changes. All money is capable of earning money at compound interest rate. Thus £100 in n years' time is worth £100 $(1.05)^n$ if 5% is the prevailing interest rate over the n years.

The value of money also changes by inflation or deflation. If inflation follows the same trend which it has shown for the past 10 years it would take £140 in four years to replace £100 worth of capital equipment bought now and £180 in eight years to replace the same equipment. In the first case we would have to recover £120 in four years by charging 30% and in the second £160 in eight years by charging 20%. On the other hand, money may deflate.

Probably the most reasonable policy is to base depreciation rates on the present value of the original investment.

No acceptable procedure is likely to be in phase with tax procedure. The final adjustments between paying dividends and taxes are the accountant's worry, not the designer's.

Works overheads

These are various charges which cannot be related directly to production. Management, staff and clerical salaries and the cost of amenities such as ambulance room, canteen and laboratories tend to remain constant in spite of variation in production. Rates and insurance are also in this category. If the process is an isolated one it should be possible to make a very good assessment of these. There is, however, a tendency to share these fixed costs between a number of processes and the task of assessment becomes increasingly complex. The best guide to works overheads will be works accounts for similar operations. For particular groups of industries in which competition and working agreements compel conformity it would seem unlikely that overhead costs would differ seriously one from another.

Included also in works overheads are certain charges directly related to the employment of labour. There are the cost of national insurance and other pension contributions or holidays with pay, provision of protective clothing and the like. These could very conveniently be added to the costs of direct labour.

Rather rough approximation of total overheads may be made by multiplying labour and supervision costs by a factor or by rating overheads as a percentage of gross returns or operating cost.

Raw materials

Stoichiometrical relationships plus laboratory data on yields will determine raw materials requirements. It is not always easy to know what unit prices to allow for certain raw materials. The figures used should be as realistic as possible because raw-materials costs can often be determining. When raw materials costs are not known exactly or when they are known to vary, a common device is to put × for the cost of raw material and state the final answer in algebraic form. A graph of selling price or production cost versus probable prices of raw materials may then be drawn. Two or more unknowns can be handled using one as abscissa and the others as parameters.

By-products

Saleable by-products are credited at something less than the market price. As the success of the process may depend upon the disposal of by-products it is as well to allow for a considerable discount. This is often better than to have to capitalise further plant for purification of the by-product or to accept the responsibility of putting an additional product on to an established market.

When the process produces two or more streams of roughly equal value it is simplest to cost the main one and treat the other as a credit item.

Return on capital

The purpose of the exercise is to find a proposition which will make an adequate return on the invested capital.

The return on capital can be calculated by subtracting production cost from selling price and expressing this difference as a percentage of capital.

Because, however, the selling price is not always known to the development engineer he will usually find it more convenient to calculate a selling price. To do this he simply adds an agreed percentage of capital investment to his production cost. The market survey expert or the investor can then commence his studies with this minimum figure in mind.

The percentage to be added must allow for packaging and marketing expenses plus head office overheads, interest on working capital (*i.e.* cost of raw materials and finished products in storage and materials in process in the plant) and for company tax. On a works production cost such as this it has been estimated that a return of from 25 to 30% is a reasonable margin to allow.

Phthalic anhydride project

Howards of Ilford Ltd. are to install a phthalic anhydride unit at their Ilford works. It will have a planned capacity of 3,000 tons p.a., and the company states that it will be based on a proved Continental design which produces a high yield of high-quality material and has been operated successfully for a period of years. Site preparation is well advanced and it is expected that the plant will be on stream by the end of 1959.

Part of the output of this plant will be utilised for Howards' own captive use in the manufacture of their specialised phthalate esters, but a substantial proportion will be available for sale.

Considerable surplus production capacity for phthalic anhydride exists both in the U.S.A. and Europe as a whole, but up to the end of last year the United Kingdom was a large importer. The major producers in the United Kingdom have recently announced increases in their production capacity and Howards estimate that, when their own plant comes on stream, the needs of the United Kingdom market for this material will be fully met from home production.

WHAT'S NEWS about

★ Plant
★ Equipment
★ Materials
★ Processes

This illustrated report on recent developments is associated with a reader service that is operated free of charge by our Enquiry Bureau. Each item appearing in these pages has a reference number appended to it; to obtain more information, fill in the top postcard attached, giving the appropriate reference number(s), and post the card (no stamp required in the United Kingdom).

Filter aids

The British Ceca Co. Ltd. are now making available *Clarcel* filter acids, manufactured in France by their associated company Société C.E.C.A. from their deposits of high-grade diatomaceous earth. **CPE 1213**

Double-deck drum loading

A tail-gate loading attachment for lorries which allows double-deck elevation of drums and barrels is being produced by Edbro-B. & E. Tippers Ltd. A swash-plate pump feeds a steady flow of oil at high pressure to the hydraulic motor. The motor, through worm gearing, rotates twin chain sprockets, coupled by a cross shaft beneath each rear corner post. Roller chains within the tail door guides provide the lifting medium.

The load is safely held at any intermediate height by powerful and positive hydraulic locks. **CPE 1214**

Liquids under pressure

Mild-steel pressure container.

Centre - top - outlet pressure containers of 5- and 10-gal. capacities, specially designed for use with liquid polishing compounds and similar heavy materials, have been introduced by Alfred Bullows & Sons Ltd. Shells of mild-steel, boiler-quality plate with dished and flanged ends are electrically welded throughout. Covers are high-tensile aluminium alloy castings and are fitted with quick-action filler caps.

Maximum working pressure is 50 p.s.i. and they are hydraulically tested to 100 p.s.i. Ram plates are fitted on both models as standard and both incorporate $\frac{3}{4}$-in. o.d. straight-through feed pipes which have no bends or obstructions, and discharge is from the centre of the container head. An outlet of $1\frac{1}{4}$ in. diam. is available. **CPE 1216**

Measuring electrolytic conductivity

New conductivity measuring cells developed by Electronic Switchgear (London) Ltd. include the CCM type, which can be suspended in open-topped tanks and process vessels for continuously monitoring the conductivity of wash and rinse waters, while the CCL, operating through a rubber bulb or polythene tube flow line, is for general laboratory use.

The CCB/E cell is a development of the high-pressure type CCB and has been specially produced for installation in steam condensate hot wells where rising and falling levels would cause the standard pattern of cell to be flooded. CCR is more compact than the CCB series and is intended for use where the heavier-duty characteristics of the CCB cells are not justified. They have stainless-steel bodies and carbon electrodes and operate up to 100 p.s.i. and 80°C. Type CCF/10 is an open-tank cell which meets requirements where it is essential that matter suspended in the solution does not clog the electrodes within the measuring cell. **CPE 1215**

Bigger bars get bored

Hollow-bored bars produced by Keeton, Sons & Co. Ltd. now include bars up to $6\frac{1}{2}$ in. bore, $10\frac{1}{2}$ in. o.d. and 18 ft. long. Hollow-bored bars or fabricated hydraulic cylinders with finished machined bores from $\frac{3}{4}$ to 10 in. diam. to a tolerance of ± 0.003 in. are also offered. Alternatively, these products are available with honed finished bores from 2 to 8 in. diam. to a tolerance of ± 0.001 in. Maximum length in either case is 15 ft.

Hollow-bored forgings, up to a limit of 28 in. o.d. and 5 tons solid weight can be supplied. On lengths up to 10 ft., the forging can be bored to a blank end, or with a bore stepped with varying diameters. **CPE 1217**

Anti-corrosion angle

Galvanised slotted angle with a 3-mil coating has been developed by Dexion Ltd. specially for outdoor structures or for use in atmospheres where normal metal is subject to corrosion. It will be available in all the standard *Dexion* sizes except 112. **CPE 1218**

Vertical glandless pump

A new series of vertical glandless pumps by Kestner Evaporator & Engineering Co. Ltd. is intended primarily for circulating rayon spin bath liquor in high-vacuum crystallisers (for the purpose of recovery)

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and for forced-circulation evaporators handling caustic soda from electrolytic cells, but also has other applications.

Type H is of the axial-flow, propeller type provided with guide vanes on both suction and delivery sides. The shaft is in mild steel with antimonial lead coating, and other sleeves in silicon iron provide anti-corrosion protection towards the bottom of the shaft. The pump body is made from regulus metal and the guide vanes, which also serve to sleeve the pump casing, are made from *Tantiron*. Steaming-out points are provided.

CPE 1219

Breaks 'em up fine

Flexibility and mobility are features of the *Fitzmill* all-purpose comminuting machine, available with water-jacketing and provision for low-temperature pulverising.

Applications include dry granulation with a minimum of fines; dustless pulverising of chemicals, crude drugs and pharmaceuticals; dispersion or wetting of fine materials in an oil-carrying agent or base; colloidal suspensions in liquids; recovery of scrap and flash; and granulation of wet ceramic masses such as steatite.

The operation of the model 'D' is based on the correct combination of screen size (from 200 mesh to $1\frac{1}{2}$ in. openings) and speeds (from 800 to 5,000 r.p.m.) to permit wet or dry materials to be processed to any desired size. The makers are Manesty Machines Ltd. **CPE 1224**

SELF-SEALS PRESSURE PIPES

Connection and disconnection of quite large pipe couplings under pressure is possible with a self-sealing coupling developed by Exactor Ltd., in which the opposing forces that are met with when connecting or disconnecting the two halves are practically balanced. The 3-in. coupling illustrated here has been coupled without undue effort when the pressure in the lines was 400 *p.s.i.*

CPE 1220

Liquid dispenser

Quick and automatic dispensing within a range of 0.1 to 20 ml. is claimed for the Struers machine, manufactured in Denmark and distributed by Camlab (Glass) Ltd. The dispenser is housed in a white, heavily enamelled, metal case and in the front is the dispensing measuring chamber, fitted with an on-and-off valve and subsidiary mechanism. For sterilising, the two main parts can be dismantled without the use of spanners. Subsequently they can be broken down into individual parts, to be sterilised in steam or in dry heat up to 200°C. maximum.

The syringe is made of borosilicate glass and all other parts which come into contact with the liquid are of stainless steel. There is no need for washers or sealing compounds and

Strains from a bung hole

A suction strainer providing a large straining area on the end of a suction pipe, at the same time enables most of the contents of a drum or narrow-necked vessel to be drained. The maximum diameter of the strainer is $1\frac{3}{4}$ in., enabling it to be placed through the bung hole on drums, carboys, etc. The contents are drawn through a large gauze surface down to the bottom holes on an internal suction tube and thence up through the outlet of the strainer.

Liquid can be drained to within $\frac{3}{8}$ in. of the bottom of the container when the strainer is standing vertical, or to within $1\frac{1}{2}$ in. of the bottom when the strainer is lying horizontal, say the makers, H. T. Watson Ltd.

Standard materials are brass and 18-8-3 stainless steel. **CPE 1221**

Fast filtering with kieselguhr

Two new grades of German kieselguhr for specialised filtration applications are available. The first, '80' *Special* kieselguhr, a white, high-quality grade with a large bulk volume, is made up of diatoms within the size range of 30 to 90 microns. This ensures full suspension during the complete filtration period. An excellent flow rate is claimed with extended period of cycle and above-average clarification.

The second, '80' *Quick* kieselguhr, is slightly off-white and gives a very fast filtration rate with medium clarification. It is specially recommended for applications where build-up of back pressure is to be delayed and when highly viscous liquids are involved.

Five other grades introduced by the distributors, Charles H. Windschuegl Ltd., have been further improved in colour and bulk density. **CPE 1222**

Has cathodic protection all screwed up

An ingenious yet simple means of preventing corrosion in auxiliary heat exchangers, small condensers, etc., is the *Galvion* anode, comprising a brass plug with B.S.P. tapered threads, and a number of high-purity zinc 'bobbins' or elements having a threaded centre steel core. The elements can thus be screwed into each other to allow adjustment of length to fit confined spaces without waste. An interference thread ensures vibration-proof service.

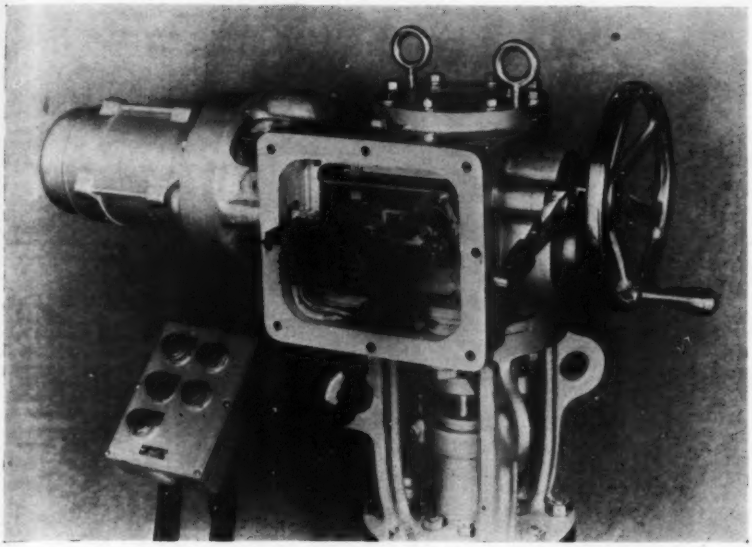
It is only necessary to drill and tap the cover of the spaces to be protected, the tapered plug thread ensuring a watertight joint without the need for sealing compounds. Existing drain plugs can often be used.

The *Galvion* anode is made in three sizes. Distributors are F. A. Hughes & Co. Ltd. **CPE 1223**

ALL-ROUND INSULATION

Onazote Insulation Co. Ltd. have recently completed the insulation of this sphere at the plant of Nitrogen Fertilisers Ltd., Flixborough, Lincs. The sphere, used for the storage of liquid ammonia at 10 *to* 15 *p.s.i. gauge, operates down to* –20°F.

The vessel has been insulated with 7 *in. of* Onazote *in four layers. It is finished in bitumenised tape.* Onazote, *with its cellular construction, was chosen for this application because of its lightness and resistance to moisture penetration.* **CPE 1225**



Electric valve operator showing geared limit and torque switches.

all moving flat faces are leakproof.

The measuring of liquid volume within the dispensing chamber is effected by a connecting rod with adjustable stroke linked to a variable-speed motor. In place of the usual valve controlling the liquid volume the equipment is fitted with a flat moving disc driven by the main crankshaft. Due to 'reverse flow' mechanism following immediately upon the stroke, the individual liquid fractions are delivered without formation of drops. **CPE 1226**

Analyses oxygen in gas streams

Null-balance magnetic oxygen analysers which instantaneously measure the oxygen content of gas streams by means of the paramagnetic effect are being manufactured under licence from the Distillers Co. Ltd. by Servomex Controls Ltd. Robustness, shock resistance and general stability have been obtained without reducing accuracy and fast response.

CPE 1227

Proof against solvents

A new coating, *Detel S/R*, which can be applied as a paint, is claimed to be resistant to a wide range of solvents, including trichloroethylene, perchlorethylene, toluol, xylol, white spirit, benzol, butanol, cyclohexanone, amyl acetate and naphtha.

It may be air-dried or stoved and a catalyst is normally used for best results. In the case of trichloroethylene or perchlorethylene, stoving is not essential, but for other solvents it is better if the coating is stoved at 120°C. for 30 min. When air-dried, it is touch-dry quite quickly, but only reaches maximum resistance to trichloroethylene after a curing period of about seven days at about 65°F. Brush or a spray can be used, although the latter is preferable. Detel Products Ltd. make it. **CPE 1228**

Lower-cost level control

Lancashire Dynamo Electronic Products Ltd. announce price reductions for their new transistorised level-control equipment. The company state that field experience on a wide range of liquids and solids at varying temperatures and pressures has proved completely satisfactory.

Granite, hot cement, coke, lime, and hydrochloric acid are among materials with which this equipment is being used. **CPE 1230**

GLASS-LINED VESSELS

We have received details of the range of acid-resistant glass-lined steel equipment which is being marketed in the United Kingdom by Q.V.F. Ltd., acting as agents for the Schwelmer Eisenwerk (Muller & Co.) of Schwelm, Westphalia.

The equipment is claimed to give a high degree of resistance to chemical attack, to extreme temperatures, and to sudden changes in temperature caused by heating and cooling processes. It is pressure- and vacuum-resistant. The non-porous glass enamel coating used in the tanks and vessels consists of several layers and may be exposed to temperatures of up to 250° and to reductions to −50°C., according to Q.V.F. Resistance to abrasion and reduction of ingredient adhesion are claimed as further features.

The equipment includes open vessels, evaporating pans, open and closed jacketed tanks, receivers, reaction kettles, storage tanks, heat exchangers and stuffing boxes. Capacities vary in most cases from 40 to 8,000 l.

CPE 1229

Controls opening and closing of valves

A fully automatic device which controls and limits the opening and closing of all types of valves is to be manufactured in the United Kingdom by Limi-Torque Valve Controls Ltd., a new subsidiary of Opperman Gears (Holdings) Ltd., Newbury. With this device, the valve can be actuated by almost any power source including electricity, air, hydraulic power and high-pressure gas. There are a number of versions for different types of service.

The *LimiTorque*, based on an American design, limits torque and thrust loads so as to protect all operating parts from overload. In the event of an obstruction being met whilst closing the valve, a torque limit switch automatically disconnects the source of motive power, thus preventing damage to valve seats, stem and discs. Seating may be adjusted to compensate for normal valve wear or other changing service conditions which may occur.

The unit makes use of precision gearing, the first reduction being by helical gear and pinion, while worm and wheel make up the second reduction and final drive. The worm is of hardened alloy steel and the worm wheel of high-tensile nickel bronze.

The worm gear drives the valve nut assembly through two lugs; this produces a 'hammer-blow' effect which allows the motor and gears to obtain full speed before torque is applied to the valve stem. This feature ensures the freeing of 'sticky' valves. In the larger units the 'hammer-blow' feature is applied to the handwheel. In effect this eliminates the possibility of the valve becoming frozen in its seating should there be a power failure. **CPE 1231**

BACKHOE EXCAVATING

A backhoe attachment for models 75A, 85A and 125A Michigan tractor shovels is now available. One lever hydraulically controls the boom action and one the bucket action. Individually adjusted outrigger feet will level the machines on slopes up to 15°.

The backhoe has travel speeds up to 27 m.p.h. and will operate over rough terrain. A series of alternative bucket sizes from 12 to 36 in. wide, and designs including trench buckets, bellhole buckets, grave and ejector buckets allow a wide variety of usage. Enquiries to Michigan (Great Britain) Ltd. or to CPE Enquiry Bureau, quoting: **CPE 1232**

Shows up the cracks

Portable magnetic crack detectors weighing 45 lb. and giving outputs of 750 amp. are being produced by R. F. Fraser-Smith. They are fitted with a change-over switch allowing operation on 100/120 or 200/250 v. a.c. single-phase supply.

Black, grey or red magnetic powders, and a full range of coloured and fluorescent magnetic inks, and safe ultra-violet viewing lamps are available. **CPE 1236**

Ball mill gets vibrations

Introduction of a new vibratory ball mill by Apex Construction Ltd.* brings the number of models to 10 and the range of working capacities from 0.5 to 250 litres.

The new mill, instead of rotating to cause the balls to cascade, is subjected to a high-frequency vibration. At the same time the balls are rotated and subject the material to impact. Materials can be pulverised to 1-micron size. At any stage of reduction the range of particle size is small, there are no excessive quantities of fine material and the mill can dispense with screening or air sizing.

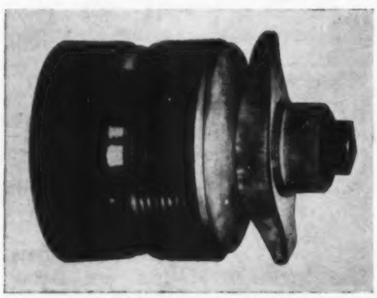
The machines are useful for the grinding and mixing of tungsten carbide and other powder-metallurgy products and applications include the processing of dyes, paint pigments, silica, ceramic batch materials, graphite, lacquers, lignite, pharmaceuticals and foodstuffs.

The smaller mills normally consist of cylindrical pots, but in the larger sizes are troughs closed with lids. The vessels are supported on springs and, by means of out-of-balance mechanism driven by an electric motor, are set in vibratory motion. Pots in the smaller sizes are of porcelain or stainless steel, whilst the larger ones are mild or stainless steel. Rubber-lined vessels are available and the larger sizes can be water-cooled. Balls are of porcelain or non-corrodible steel. **CPE 1237**

Pipe stopper

A cone lock stopper is available for plugging open-ended steel pipe and pipe fittings for testing under pressures up to 2,000 p.s.i. Claimed to be absolutely safe, it can be fitted and removed in minutes—eliminating the need for the welding up of not only pipe ends, but bullplugs, blanks, vents, feed and gauge connections.

CPE 1233



Cone lock stopper.

Water deioniser

A new deioniser by Elga Products Ltd. has all exposed components in corrosion-resistant plastic. Equilibrium water may be drawn at the rate of up to 10 gal./hr. and distilled-quality water at 20 gal./hr.

One version of this unit is for use where the main requirements are for commercial-grade distilled water; a capacity and exhaustion indicator is incorporated. Another version is used for critical applications; a conductivity monitor forms an integral part of the unit, and gives quality check throughout the exhaustion cycle.

It is possible to pipe deionised water to any number of draw-off points. No regeneration *in situ* is necessary. **CPE 1234**

Quick couple

A quick-action pipe coupling for use on rigid or flexible pneumatic or hydraulic pipelines has been developed by Simon Handling Engineers Ltd. Lever and claw fastenings make or break connections and a fitted rubber sealing ring gives an airtight connection capable of withstanding considerable pressures.

Each coupling consists of two rings with flanged ends. Fixed to one ring are the spring-loaded claw fasteners which close over the joint.

Levers and claws slide over any surface and, when the connection is broken, the toggles are spring-loaded against the pipe to minimise damage risks. Couplings are made for welding on to 2 to 8-in. thin-walled rigid or flexible pipes and for screwing on to heavier pipes. **CPE 1235**

LINED PICKLING TANK

A new mild-steel pickling tank under construction by Tanks & Linings Ltd. at the Shepcote Lane works of Firth-Vickers Stainless Steels Ltd., Sheffield. The 135-ft.-long tank is used to remove scale and prepare the stainless-steel strip for further processing. It is lined with 'Velbex' produced by B X Plastics Ltd. CPE 1238

'V' mixer with a difference

Use of a V-shaped container in a powder mixer produced by Moritz Chemical Engineering Co. Ltd. eliminates any internal working parts, glands, etc., and the unit is, therefore, easy to clean and maintain. The mixing efficiency is claimed to be extremely high, powders or granules of widely differing specific gravities and proportions being perfectly blended in a matter of minutes.

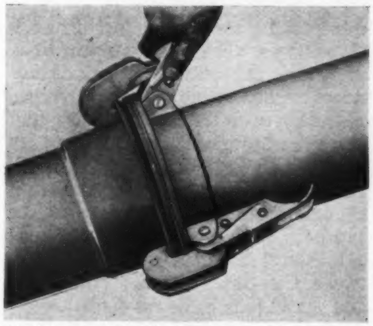
V-type mixers which have appeared in the U.S.A. revolve round an axis crossing the base of the 'V.' The Moritz design uses a similar V-shaped vessel but it revolves in a plane perpendicular to that of the 'V.' This ensures that the powders pass from one arm to the other on each rotation.

The mixer comprises a simple mechanical drive needing little maintenance. Containers are available in stainless steel, mild steel, plastic, etc. The mixer is made in six different sizes. **CPE 1239**

TWO-FACED LABORATORY EQUIPMENT

Stelvetite, sheet steel bonded to PVC, has been used by the Electro-Chemical Engineering Co. Ltd. for bench tops, fume ducting and the casing of an instrument panel in a laboratory recently completed at their Sheerwater factory. The material, produced by John Summers & Sons Ltd., is resistant to acids and alkalis within wide limits and also to abrasion, humidity, oils and greases. It has good electrical properties, does not support combustion, withstands considerable heat and can be cleaned with detergents.

In the construction of the bench tops, which are used for plating tests, *Stelvetite* was formed round a wood base and PVC filler paste used to finish the corners. For the fume ducting, the plastic side was faced internally and the electro-zinc-coated side was painted. **CPE 1240**



Quick coupling (see bottom of page 182)

American Developments in Brief

A new high-speed attrition grinding mill by Morehouse International has been designed for small and medium-size manufacturers and is simple to operate. According to the makers it can be easily cleaned and changed over to another product in a few minutes without contamination. Micrometer adjustment of stones sets clearances to within 0.001 of an inch, making possible exact duplication of products. **CPE 1241**

* * *

Flakers with internally jacketed fabricated drums 60 in. in diam. and 120 in. long with polished chrome-plated surfaces are made by Goslin-Birmingham Manufacturing Co. Inc. Vapour enclosure protects against product contamination and confines obnoxious vapours. **CPE 1242**

* * *

A device that determines the temperature at which deflection and penetration occur in thermoplastics is made by the American Instrument Co. Inc. Bath temperature can be increased at the rate of 2°C./min. from ambient to 260°C., or maintained constant at any point within this range. **CPE 1243**

* * *

A new method for fabricating shapes and applying coatings that will withstand temperatures above 5,000°F. is announced by the Linde department of Union Carbide International Co. The process uses controlled temperatures up to 30,000° and is claimed to make possible the fast and accurate mass production of ultra-hard materials that have been virtually unworkable by any conventional means in the past.

The key to the method is a plasma arc torch, the metal or substance to be worked being prepared in either wire or powder form and then passed through an intense arc that is struck inside the torch.

In addition to experimental rocket and missile parts of pure tungsten or tungsten-coated graphite, the new torch has already been used to produce high-density tungsten crucibles for metallurgical purposes, special parts for nuclear work, sensitive electrical contacts, and electronic components and *x*-ray targets of superior density. **CPE 1244**

* * *

A complete line of lightweight L.P. gas appliances has been added to *Prest-O-Lite* soldering, heating and brazing equipment by the Linde Department, Union Carbide International Co. Open-flame torch stems in six sizes and an enclosed-flame soldering iron stem are included, all of which fit interchangeably on three styles of torch handles. **CPE 1245**

* * *

Three new ultra-micro *KBr* sampling accessories, extending the use of infra-red analysis of solids with the model 21 infra-red spectrophotometer, have been developed by the Perkin-Elmer Corporation. It is an all-reflecting system of optics for condensing six times the infra-red sample beam, and maintains high energy levels when analysing samples as small as 0.5 mm. diam. **CPE 1246**

* * *

The use of Du Pont fuel oil additive No. 2 (FOA-2) resulted in substantial savings in a plant which reported that about 80 lb. of the chemical made it unnecessary to clean mechanically a 17,000-gal. storage tank. The plant, which uses about 3 million gal. of No. 6 residual fuel oil p.a., found that sludge was building up to a depth of several feet in the tank so rapidly that two to three cleanings a year were necessary **CPE 1247**

* * *

A new type of infra-red detector, utilising the photo-conductive effect of indium antimonide, is being manufactured by Radiation Electronics Corporation. **CPE 1248**

* * *

Fire hose made of a neoprene tube, jacketed with neoprene-coated *Dacron* polyester fibre, is gaining in use at industrial plants where attack by mildew, harmful chemicals and fumes occurs. The Fortier plant of American Cynamid Co. is using hose of these materials—made by the Quaker Rubber Division of the H. K. Porter Co.—as old hose wears out. **CPE 1249**

ORDERS AND CONTRACTS

The United Kingdom Atomic Energy Authority has awarded a contract to W. J. Fraser & Co. Ltd. for the design of a plant to recover radioactive caesium from highly active waste materials produced in the processing of irradiated fuel.

Over the past few years several Fraser engineers have attended the Authority's training schemes and, now back in the organisation, will play their part in designing this plant.

*

The M. W. Kellogg Co., U.S.A., subsidiary of Pullman Inc., received a lump sum contract for approximately \$30 million to engineer and construct a 500-ton kraft pulp and liner board plant for the Tennessee River Pulp & Paper Co. The plant will be located at Counce, Tennessee.

Kellogg has entered into a subcontract with H. A. Simons Ltd. of Vancouver to assist in the design of the plant. Initial construction operations have started and the construction schedule calls for completion by January 1, 1961.

*

Head Wrightson Stockton Forge Ltd. have recently supplied to I.C.I. Ltd. two driers, four ball mills and two coolers. The driers are of the parallel-flow, single-shell type, 12 ft. diam. by 90 ft. long, with a capacity of some 180 tons/hr. They will be used in the production of fertilisers. To ease transport and erection and also to assist in alignment, the shells were made in three pieces, the joints being machined with spigoted flanges, connected on site by fitted bolts.

The four ball mills are 7 ft. in diam. by 7 ft. long and each mill is driven by machine-cut spur gears through reduction gears and flexible couplings from 200-h.p. motors.

One of the coolers is 12 ft. in diam. by 75 ft. long and the other 11 ft. in diam. by 70 ft. long and will be used for handling similar materials to the driers. They are arranged for counter-flow working.

*

The General Electric Co. Ltd., United Kingdom, is to build Japan's first nuclear power station at Tokai-Mura, some 70 miles north-east of Tokyo. The value of the contract approaches £20 million and the 150-Mw. station will take about four years to build.

The design of this single-reactor power station which was submitted by G.E.C. in collaboration with Simon-Carves Ltd. allows for the safety of the installation under earthquake conditions. In its basic elements, the reactor is similar to those already being built for the British nuclear power programme, with natural uranium fuel elements mounted in vertical channels through the reactor core. The reactor is provided with the usual type of control system employing neutron-absorbing control rods which can be raised and lowered in vertical channels interposed between the fuel channels through the core. In addition, however, an independent alternative shut-down device, which can be tripped manually, operates automatically under severe earthquake conditions.

The United Kingdom Atomic Energy Authority has received a letter of intent to supply fuel for the Japanese station. At the same time a technical assistance agreement between the Japan Atomic Power Co. and the U.K.A.E.A. was signed.

*

The Power-Gas Corporation (Australasia) Pty. Ltd., Australian subsidiary of the Power-Gas Corporation Ltd., Stockton-on-Tees, has received an order worth £A800,000 for one unit of carburetted water-gas plant from the Australian Gas Light Co. for their Mortlake works, Sydney. It will have a normal capacity of 9 million cu.ft./day of 550 B.Th.U. gas, with a peak load capacity of 12 million cu.ft./day.

The unit will incorporate a generator of the dry-base type and will utilise the reverse flow carburetting system for the use of heavy oil. A unique feature of the plant is that, except for certain control equipment, it will not be housed, thus following a similar trend adopted in recent years for catalytic oil gas plants.

Special equipment will be manufactured and the engineering will be carried out at Stockton-on-Tees. Auxiliary equipment will also be supplied from this country.

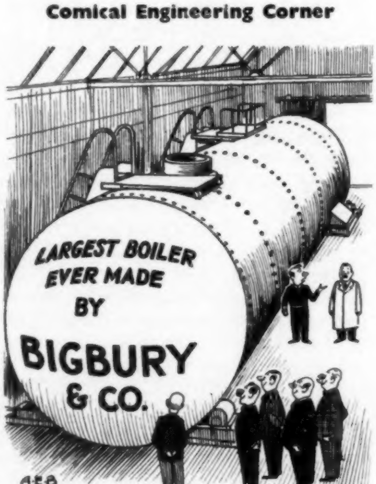
*

The engineering and construction contract for the Dow Agrochemicals plant at King's Lynn, Norfolk, for the manufacture of *Dowpon*, a selective weed killer, has been awarded to Constructors John Brown Ltd. The project, estimated at a million pounds, is due for completion by mid-1960.

*

For handling West Northamptonshire iron ore, two rotary drum driers have been ordered from Buell (1952) Ltd., a subsidiary company of Edgar Allen & Co. Ltd. Each drum measures 9 ft. 2 in. diam. and 46 ft. long, and has a capacity of 50 tons/hr. of wet ore, sized $2\frac{1}{2}$ in. to 0 in.

Comical Engineering Corner



'WELL, SOMEBODY'S GOT TO TELL 'EM WE CAN'T GET IT OUT'

COMPANY NEWS

Shell oil and chemicals

Four new subsidiaries of the Shell Petroleum Co. Ltd. and Bataafse Petroleum Maatschappij N.V., have come into operation. They will take over certain supply activities and responsibility for giving advice and services to the many operating companies throughout the world which make up the Royal Dutch/Shell Group. Shell Petroleum and B.P.M. will henceforward function mainly in a shareholding capacity.

The new companies are (for oil) Shell International Petroleum Co. Ltd. (London), Bataafse Internationale Petroleum Mij. N.V. (The Hague); (for chemicals) Shell International Chemical Co. Ltd. (London), Bataafse Internationale Chemie Mij. N.V. (The Hague).

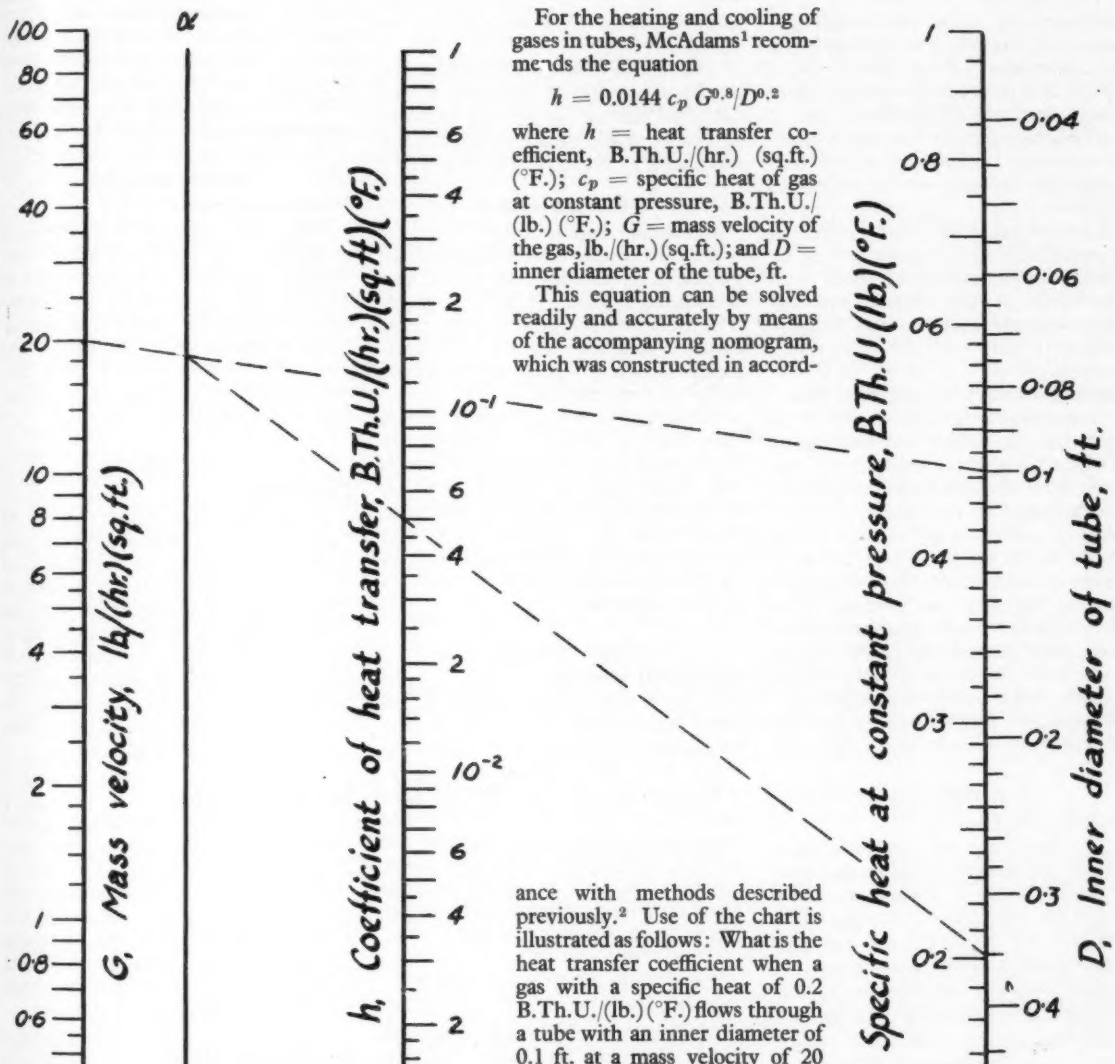
Mechanical handling

The mechanical-handling division of Teleflex Products Ltd. has moved from Chadwell Heath to Basildon New Town, Essex. Occupying 50,000 sq. ft. with land for further expansion, it is adjacent to the remote-controls division which has been operating there since 1955.

NOMOGRAM

By D. S. Davis

Heating and Cooling of Gases in Tubes



For the heating and cooling of gases in tubes, McAdams[1] recommends the equation

$$h = 0.0144\, c_p\, G^{0.8}/D^{0.2}$$

where h = heat transfer coefficient, B.Th.U./(hr.) (sq.ft.) (°F.); c_p = specific heat of gas at constant pressure, B.Th.U./(lb.) (°F.); G = mass velocity of the gas, lb./(hr.) (sq.ft.); and D = inner diameter of the tube, ft.

This equation can be solved readily and accurately by means of the accompanying nomogram, which was constructed in accordance with methods described previously.[2] Use of the chart is illustrated as follows: What is the heat transfer coefficient when a gas with a specific heat of 0.2 B.Th.U./(lb.) (°F.) flows through a tube with an inner diameter of 0.1 ft. at a mass velocity of 20 lb./(hr.) (sq.ft.)? Following the key, connect 20 on the G-scale and 0.1 on the D-scale with a straight line and mark the intersection with the α-axis. Connect this point and 0.2 on the c_p-scale with a straight line and read the desired heat transfer coefficient on the scale as 5.0×10^{-2}.

REFERENCES

[1]W. H. McAdams, 'Heat Transmission,' 3rd ed., p. 226. McGraw-Hill Book Co. Inc., New York, 1954.

[2]D. S. Davis, 'Nomography and Empirical Equations,' Chap. 6. Reinhold Publishing Corporation, New York, 1955.

World News

NORWAY

Aluminium expansion

The Mosjöen Aluminium A/S, which started operation a year ago, was recently reported to be completing the installation of 16 new furnaces which will increase production capacity from 22,000 to 25,000 tons p.a.

There are further expansion plans for another 32 furnaces, which will bring the capacity up to 30,000 to 32,000 tons.

The ' Mosal ' plant, which is located in north Norway, is owned jointly by the Elektrokemisk A/S, Oslo, with two-thirds of the shares, and the Swiss concern Aluminium Industrie A.G.

Explosives cartridging machine

Norsk Spraengstofindustri A/S, Oslo, has patented a new cartridging machine for gelatine explosives. Developed by Nitroglyserin Compagniet, a subsidiary, it incorporates a pre-packing and packing system which obviates the use of a separate shell machine and handles the gelatine with extreme leniency, so avoiding pressures which could endanger operations, particularly where foreign matter is present. Rights have been sold to Canada, and a European manufacturer of explosives has acquired rights for all territories outside North America.

ITALY

Fish flour plant

The first full-scale commercial plant for the production of edible fish flour is being built in Sweden and will come into operation this year. This was recently reported to the Food and Agricultural Organisation, Rome, by representatives of the largest pharmaceutical manufacturing company in Sweden.

ISRAEL

Chloric acid separation

An experimental pilot plant for the separation of chloric acid from magnesium oxide and hydrochloric acid by a thermal method will be set up in the Dead Sea region. Operations will be conducted according to the Amann process.

UNITED STATES

Ethylene oxide project

Plans for the construction of a plant to produce ethylene oxide and derivatives in Italy have been announced by Union Carbide Corporation. The unit will contribute to the expanding activities of S.p.A. Celene, a company formed in 1957 by Union Carbide Corporation and Societa Edison of Milan.

The new installation will be adjacent to Celene's polythene unit near Prioli, Sicily. Plans call for annual capacity of 12,000 metric tons with production scheduled to commence in mid-1960.

NEW ZEALAND

Aluminium fabrication

The Northern Aluminium Co. of Britain is to establish an aluminium fabricating industry in New Zealand. The plant would have a production capacity of 5,000 tons p.a. of aluminium sheet plus 2,000 tons of aluminium wire and cables.

According to a news agency report the venture would be backed by Aluminium Ltd. of Canada, of which the British firm is a subsidiary. A spokesman for Aluminium Ltd. said there would be an initial investment of approximately £2 million provided by the Canadian company and its British subsidiary.

GUATEMALA

Industrial projects

Projects under way include a new paint factory with United States participation; a factory for processing kenaf fibre with British machinery; a cellulose factory; a sulphuric acid and caustic soda factory; a textile finishing factory; new capacity for textiles, paper, rope, sweet and chewing gum factories; a canning plant for fruit juices and a plant to manufacture fats and oils from cottonseed.

RHODESIA AND NYASALAND

Oil and rubber

Investigations by Anglo-American Corporation into the project for producing oil from coal have continued and recent developments, described as ' promising,' give rise to talk of a £13-million scheme.

MEXICO

Pulp and paper industries

The wood-pulp and plywood manufacturing firm, Celulosa de Chihuahua, whose plant and machinery are almost entirely Italian-made, have reaffirmed their intention to increase production by 50%. The same group are planning to install a new factory to make white paper at a cost of 15 million pesos.

The Compania Industrial de San Cristobal are producing 90 tons/day of unbleached pulp and 65 tons of bleached pulp, largely from sugar cane, but also from wheat chaff. It is also producing 40 tons/day of paper, using 70% sugar cane and 30% other pulps bought in Mexico. The company is associated with the Scott Paper Co. of Pennsylvania, who provided a $2-million credit, with technical advice and machinery.

SOUTH AFRICA

Manganese plant

The first part of a £12-million manganese ore reduction plant—two electric furnaces that will produce 120 tons/day of high-carbon ferro-manganese—will start production shortly at Cato Ridge, near Durban. The plant will eventually have eight furnaces, and draw ore from the Kuruman area of the Northern Cape.

POLAND

Petroleum

A 2-million-ton refinery is to be built at Plock instead of Konin. At present Poland imports about 50% of its petroleum products and output at Plock alone should cover 70% of her requirements. A petrochemical industry associated with the refinery will manufacture artificial fibres, synthetic rubber, etc. Specialists are to be trained in the U.S.S.R. and construction should start in 1960.

Synthetic rubber

The first Polish synthetic rubber plant will be completed at Oswiecim chemical works during 1959 and an output of 1,500 tons is planned by the end of the year. Production in 1960 should reach 20,000 tons and thereafter should proceed at a rate of 36,000 tons p.a. It will be based primarily on synthetic alcohol.

Man-made fibres

According to the 1961-65 plan the production of artificial fibres in 1965, based on imported cellulose, should amount to 116,000 tons, an increase of 76% over 1958. The production of synthetic fibres (nylon, *Steelon*, etc.) is to be increased 15 times between 1959 and 1965 to reach a total of one-third of the entire production of man-made fibres. Efforts are in hand to produce sufficient cellulose in Poland to avoid expensive imports from Finland and Sweden. In the second half of 1957, 250 tons of sulphite cellulose were produced, but shortage of chlorine is a bottleneck.

Industry Must Use Its Technical Literature

LESSONS OF A.B.C.M./B.C.P.M.A. DISTILLATION PANEL INVESTIGATIONS

TOO many firms are not making sufficient use of the available technical literature in order to improve the efficiency of their manufactured processes. This is one of the facts discovered by the special panel set up by the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers Association to investigate 'gaps' in research on distillation, and ways in which these gaps could be filled. It would also appear that some of the conclusions of the well-known Cremer Committee where certain fields of research are concerned are misleading—not through any fault of the committee, but because a number of apparent gaps in research have been reported in ignorance by companies who have not taken the trouble to secure available literature on the subject in question.

This situation was brought to light at a special meeting in London when the findings of the panel were revealed to CHEMICAL & PROCESS ENGINEERING and certain other technical journals by leading personalities connected with the A.B.C.M./B.C.P.M.A. investigations, including Mr. E. W. Greensmith (chairman, A.B.C.M. Chemical Engineering Research and Advisory Service Committee), Mr. A. G. Grant (first chairman of B.C.P.M.A. Research Committee), Mr. L. Holliday (chairman, Distillation Panel), Mr. S. C. M. Salter (secretary, B.C.P.M.A. Research Committee), Mr. G. Brearley (director, A.B.C.M.), Mr. O. G. Weller (secretary, Chemical Engineering Research and Advisory Service Committee and Distillation Panel) and Mr. H. W. Vallender (commercial section senior technical executive officer, A.B.C.M.).

The report of the Distillation Panel has now been released for general publication and we shall be publishing a commentary on it next month. Here we are only concerned with the wider implications of the panel's revelations, for the ignorance and apathy of many companies with respect to research matters undoubtedly extends to many other fields besides distillation.

The ubiquity of chemical engineering is something that has constantly been stressed in CHEMICAL & PROCESS ENGINEERING, and so it comes as no surprise to us to learn that the panel found chemical engineering research going on in various research centres on behalf of the laundry, leather and miscellaneous other industries. What is important is that this research is not finding its way into the sum total of reported chemical engineering advances. Perhaps this is due to the fact, as implied in our commentary on page 151, that there are quite a number of people doing chemical engineering work who are not very clear as to what chemical engineering is all about.

But the matter of most vital concern to us is this apparent failure by industry to make full use of technical literature, because as a technical journal we take great pains to present our readers with all that is new and useful in our field. In our series of 'Chemical Engineering Reviews' for instance (the one in this issue is on fractional distillation) we give all the latest references on the more practical aspects of distillation, filtration, heat transfer, drying and other vital operations. If industry is not making good use even of such general reviews as this to keep itself up-to-date this is indeed a deplorable situation.

We cannot express too strongly our feeling that every industrial company which wishes to survive in this competitive age should procure all technical literature relevant and useful to the efficiency of its industrial operations and, moreover, that it should ensure that sufficient copies of each publication are available and that they are seen and read by the members of their staff most concerned with that particular subject.

The A.B.C.M./B.C.P.M.A. Distillation Panel did indeed find some gaps in research on distillation and we shall be reporting on these in our next issue. However, it seems apparent that, as far as chemical engineering is concerned, there is little justification in the often repeated assertion that not enough money is being spent on research in Britain. We are assured that a great volume of chemical engineering research is being done by the universities and by private firms, as well as the research associations and other bodies. It would seem that the answer to industry's technical problems is not, as has been suggested, to set up some big new centre of research information, but to educate firms as to how they can obtain the research information they need and how they can harness it to their needs.

INDUSTRY REPORTS . . .

Monsanto progress

A comparison with the prices for 100 important raw materials in 1958 as against 1953 showed that 34 have decreased in price, 51 have increased by amounts up to 20% and 15 by amounts up to 50%, said Sir Miles Thomas, chairman of Monsanto Chemicals Ltd., in his annual statement.

The company's greatest single effort in the expansion of its operations was concentrated at Fawley, where very rapid progress was made in building the new polythene plant and ancillary buildings.

Sir Miles said the growing demand for phthalic and maleic anhydrides in the United Kingdom has created a situation that calls for further expansion in the production of these important basic chemicals. The company commissioned new plants during 1958.

Turning to phenol, the company's oldest product, Sir Miles referred to the major expansion at the Ruabon factory. The completion of this expansion took place shortly before the end of 1958. It converted the production process from batch to continuous operation.

Expenditure on capital projects during 1958 amounted to £3,461,106. Monsanto investments in associated and subsidiary companies yielded dividends amounting to £259,472 before deduction of U.K. tax, as compared with £144,230 in 1957.

Chemicals in Canada

'Generally unsettled' conditions in the chemical industry during 1958 were referred to in the annual report of Mr. J. A. Fuller, president of the Shawinigan Water & Power Co. (Canada). During the year the assets and plant of St. Maurice Chemicals Ltd., previously owned jointly by Shawinigan Chemicals and Heyden Newport Chemical Corporation, were acquired and its manufacturing facilities at Varennes, Que., integrated into

the operations of Shawinigan Chemicals. In 1958 also the new caustic soda and chlorine plant at Shawinigan was completed.

Capital expenditures during the year amounted to $1,324,000, which included $1,015,000 for completion of the new caustic soda-chlorine plant.

B.A.-Shawinigan Ltd. increased its manufacturing facilities to bring phenol production capacity to 30 million lb. p.a.

In the United Kingdom the operations of Hedon Chemicals Ltd., which commenced operations in mid-1956, became profitable in 1958.

Too much aluminium?

Total aluminium smelting capacity in the free world increased from about 3,600,000 tons at the beginning of 1958 to 4,100,000 tons at its end, according to the general review of Mr. N. V. Davis, president of Aluminium Ltd. It seems likely that the producing industry must look forward to a condition of over-supply for the next few years, he said.

In the United Kingdom expansion is being undertaken by Northern Aluminium Co. to increase the capacity of its rolling mills at Rogerstone from 50,000 to 75,000 tons p.a. of sheet products, with provision for another 100,000 tons when required.

A new 270,000-ton-p.a. alumina plant at Ewarton, Jamaica, will be completed in mid-1959 and another plant of 245,000 tons' capacity at Mackenzie, British Guiana, will be completed late in 1960. In the light of conditions prevailing in the industry, the constructions schedule of the company's French subsidiary, Bauxites du Midi, in Guinea, must be revised. The project, to exploit the bauxite deposits at Boké, requires another six years' work before it is completed. The operation of bauxite installations in the Los Islands of Guinea is continuing.

Research developments include a machine to replace hand welding of circumferential joints of aluminium pipe, and an improved alloy for bright anodising.

The Leonard Hill Technical Group—May

Articles appearing in some of our associate journals this month include:

Petroleum—Reforming with RD 150 Platinum Catalyst; Recent Developments in the Oxo Process; Heat Transfer to Liquids in Intermittent Flow.

Paint Manufacture—Silicone Resins in Surface Coatings; Selection of Suitable Solvents for Nitrocellulose Lacquers.

Manufacturing Chemist — Expansion in the Pharmaceutical Industry; Wellcome's New Vaccine Laboratories at Beckenham; Interferon—A New Approach to Virus Chemotherapy; 2-Vinyl Pyridine—A Versatile Intermediate; Report on the Cosmetic Congress; Disinfectants and Disinfection.

Automation Progress — Data Logging in Chemical Plant; Superconducting Computing Devices; The Present State of Digital Technique.

Food Manufacture—Fruit and Vegetable Canning and Quick Freezing; Mechanical Handling for the Food Industry.

Dairy Engineering—Linings for Milk Tankers; Dairy Engineering Developments in Eastern Europe.

★ *Personal Paragraphs* ★

★ **Sir Ewart Smith,** F.R.S., has retired from the board of Imperial Chemical Industries Ltd. An engineer of distinction, he joined Synthetic Ammonia & Nitrates Ltd. (later the Billingham division of I.C.I.) in 1923, just before the start-up of the first plant, and subsequently played a part in the major development of the huge Billingham complex, becoming its chief engineer in 1932. He was seconded to the Ministry of Supply in 1942 to be chief engineer and superintendent of armament design. He returned to I.C.I. in 1945, when he was appointed technical director. His responsibilities in this capacity, and from 1955 onwards as a deputy chairman of the company, did not preclude his devoting a great deal of time and energy to other organisations concerned with increasing productivity, and the harnessing of work study and other modern techniques of management to this end. He has also taken a personal lead in alerting industry to the importance of safety in operations, and I.C.I.'s achievements in this connection are due in no small measure to policies that he initiated. In addition, Sir Ewart has served on numerous other bodies, governmental and scientific.

★ **Mr. D. C. Gunn** has been appointed chief engineer to Cochran & Co., Annan, Ltd. He was formerly deputy director of the British Coal Utilisation Research Association.

★ **Mr. D. J. Bird,** a vice-chairman of Fisons Ltd., has retired from the company, at the age of 65, after 30 years' service. He is a past-president of the Fertilizer Manufacturers' Association and during World War 2 was Deputy Controller of the Fertilizer Control at the Ministry of Supply, later being appointed Controller of Miscellaneous Chemicals for the Government. He was president of the International Superphosphate Manufacturers' Association from 1953 to 1955. Mr. Bird's connection with Fisons began in 1929 when, on the amalgamation of Prentice Bros. Ltd. with Fisons & Packards, he joined the Fison board as one of the sales directors. On his return to Fisons after the war, he was appointed chief sales director. He became a vice-chairman in 1954.

★ **Mr. L. G. Orriss** has been appointed sales representative of Normand Electrical Co. Ltd. and Neco Geared Motors Ltd. for London and the Home Counties except Kent and Essex. **Mr. W. A. Shufflebottom** has been appointed sales representative for Lancashire, Yorkshire and Cheshire.

★ **Sir Ashley S. Ward,** the well-known Sheffield industrialist, died recently at the age of 81 after a short illness in a London hospital. He was president of Thos. W. Ward Ltd., chairman of the Park Gate Iron & Steel Co. Ltd., Rotherham, vice-chairman of Laycock Engineering Co. Ltd., and a local director of the National Provincial Bank Ltd.

A nephew of Thomas W. Ward, the founder, he joined the firm as a young man. He was afterwards sent to London to promote Ward's interests in the south, and subsequently established the extensive Silvertown works. He became successively assistant managing director, joint managing director and in 1941 was appointed chairman and managing director on the death of Dr. Joseph Ward, a younger brother of the founder of the firm. He was knighted in 1958 for political and public services.

Nylon sifting cloth. A booklet by Henry Simon Ltd., Cheadle Heath, Stockport, contains comprehensive tables of meshes and aperture sizes throughout their range of nylon sifting cloth. It also gives information on the physical, chemical and storage properties of nylon.

Recent British Patents

Descaling metals

Descaling baths of molten sodium hydroxide containing up to 20% of sodium hydride are well known for treating stainless steel, but are unsatisfactory for descaling low-grade carbon steels, because the reduced scale adheres firmly to the metal surface and is expensive to remove.

It is now proposed to improve the existing process by the addition of iron to the molten bath, to the extent of 0.2 to 10%, preferably 0.3 to 1% calculated as metallic iron. It is preferred to add the iron in the form of an oxide. The sodium hydride proportion is from 0.3 to 5% of the total weight of the composition.

Workpieces to be descaled are brushed, if desired, and immersed in the molten bath for 30 sec. to 30 min., according to the thickness of the scale. The bath temperature is from 325 to 550°C., preferably about 500°C. After immersion the workpieces are removed and quenched in water while still hot. It is claimed that substantially all the scale is removed by the quenching operation, further treatment being usually unnecessary. —803,727, *E. I. du Pont de Nemours and Co.* (*U.S.A.*).

Continuous production of high linear polymers

In the production of polyethylene terephthalate continuously by ester exchange, an improvement is introduced whereby the liquid polymer level in the finisher vessel is controlled without disturbing other stages of preparation. The primary reagents form a monomer which is prepolymerised to a polymer of low molecular weight, which, in turn, further polymerises to one of high molecular weight, all the stages being continuous. The improvement consists of dissolving in the monomer controlled amounts of particles of solid polymer, of the same molecular weight as the high polymer. By this means, the level of liquid polymer in the final polymerisation vessel is substantially controlled.

In an example, ethylene glycol and dimethyl terephthalate were caused to react in a continuous ester exchange column. A continuous supply was obtained of a liquid consisting of bis-2-hydroxy ethyl terephthalate and a low molecular weight polymer thereof, the degree of polymerisation being less than 4. Dimethyl terephthalate was supplied at the rate of 100 lb./hr., the molar ratio of ethylene glycol to the former being 2.1: 1. In a vessel fitted with means of agitation, the liquid was kept at about 235°C. Polyethylene terephthalate flake was continuously added at the rate of 25 lb./hr. Details are given of the pre-polymerisation and of the final polymerisation, after which the product was extruded. The process is illustrated diagrammatically by a drawing. —801,813, *E. I. du Pont de Nemours & Co.* (*U.S.A.*).

Separation of uranium

The invention relates to the separation of unchanged uranium from plutonium and fission products of the irradiation of uranium with neutrons. The separation is carried out by extraction of an aqueous solution by an immiscible organic solvent in the presence of a salting-out agent.

In its preferred form, the process consists of dissolving the irradiated material in concentrated nitric acid. The acidity is then reduced, by concentrated ammonium hydroxide, so that free acid is not in excess of 0.05 normal. A salting-out agent, such as the nitrate of ammonium, sodium, or magnesium, is added, before or after adjusting the acidity. The solution is then treated with the organic extractant, preferably di-ethyl ether, in successive portions. It is very important that the acidity of the solution should be kept very low, as the quantity of plutonium taken up by the ether increases with higher acidity. — 805,001, *United Kingdom Atomic Energy Authority.*

Sintered magnesia

Magnesia for refractory purposes is made by heating magnesite (magnesium carbonate) at temperatures above 1,600°C. All magnesites are not suitable raw materials. Some sinter at very high temperatures, generally higher than 2,000°C. Others, which sinter more readily, do not give satisfactory refractory materials. It is known that the best results are obtained with magnesites having a high content of ferric oxide and a low content of both silica and lime. It is also known that pyrite ashes or iron ore can be added to the material to lower to sintering temperature and improve the refractory quality.

The patentees proceed a step further in adding, not solid iron compounds, but solutions in water of ferrous salts of organic acids. Ferrous salts are preferred to ferric, because the percentage of iron in them is greater. Organic salts mentioned are ferrous lactate, citrate, and acetate. The aqueous solutions are mixed with powdered magnesite. The mass is stirred until completely dry, then baked at about 1,600°C. in an oxidising atmosphere.—803,358, *Terni Societa per l'Industria e l'Elettricita* (*Italy*).

Alumina catalyst carrier for hydrogenation

For the hydrogenation, under pressure, of hydrocarbons in the gaseous phase, as well as for dehydrogenation, isomerising and other reactions, at temperatures between 200 and 600°C., it is common to use alumina as a catalyst support. The alumina is prepared by precipitation from a solution of an aluminium salt. The present invention relates to a particular method of effecting the precipitation, by which a specially active catalyst is obtained.

Aluminium salts such as halides, sulphate, nitrate, etc., are caused to react with solutions of ammonia or ammonium salts, the *p*H value being between 7 and 11, and the temperature above 40°C., preferably between 70 and 95°C. The solutions are mixed, not in a large vessel, but at the orifice of a device which practically consists of two concentric jets. Alternatively, a turbo-mixer may also be used.

Further, instead of the above reagents, a solution of an aluminate may be used, the precipitant being an acid substance. In this case the *p*H is between 4 and 8. If the precipitant is gaseous, the apparatus consists of a vertical cylindrical tower or tubular furnace, in which the gas passes countercurrently to the liquid. The temperature is from 20 to 50°C. The precipitates from both variants of the process are heated for some time at about 100°C., washed, dried, and heated.

The alumina, made into pellets, granules, etc., as required, is impregnated with compounds of metals to

obtain the desired catalysts. The metals include vanadium, molybdenum, tungsten, chromium, tin, titanium, lead, zinc, and many others. The preparation and impregnation of the alumina and catalysts as well as their final heat treatments are fully described in examples.—803,261, *Badische Anilin- & Soda Fabrik* (*Germany*).

Magnesium alloy

The invention relates particularly to magnesium-base alloys containing thorium, zinc and zirconium. Hitherto these have proved too costly in proportion to the mechanical properties obtained, largely because of the high thorium content. It is now claimed that desirable properties such as extreme lightness, high corrosion resistance and high strength may be achieved by incorporating a proportion of a rare earth metal, selected from the group consisting of cerium, lanthanum, praseodymium, neodymium and mischmetal, the last containing 35 to 80% of cerium.

The new alloy contains 0.2 to 1.2% of zinc, 0.4 to 0.8% of zirconium, from 0.1 to 0.75% of thorium and from 0.1 to 1.0% of rare earth metal, the balance being magnesium. The zirconium is soluble in hydrochloric acid and dissolved thereby when the alloy is treated with it, this being a criterion of the alloying, since unalloyed zirconium is not dissolved by hydrochloric acid.

The alloy may readily be rolled hot and annealed. It is stated to possess high strength at room temperature as well as at moderately elevated temperatures, such as up to 600°F.—801,865, *The Dow Chemical Co.* (*U.S.A.*).

The foregoing abstracts are published by permission of the Controller of Her Majesty's Stationery Office. Copies of specifications can be obtained from the Patent Office, 25 Southampton Buildings, Chancery Lane, London, W.C.2, price 3s. 6d. each.

Technology Notebook

Nuclear technology

Courses of instruction and post-graduate research in the various branches of nuclear science and engineering are being offered at the Imperial College, London. A new course in nuclear technology (chemical) is now announced and will start in October, administered by the Department of Chemical Engineering. In addition to topics related to nuclear power production, such as fuel-element technology and the processing of irradiated fuels, a substantial part of the course will be devoted to the applications of radio-isotopes as tracers and for non-destructive testing, and the possible uses of sources of radiation for inducing industrial-scale chemical reactions.

Further details can be obtained from the Registrar, Imperial College of Science and Technology, London, S.W.7.

I.Chem.E. 'Regulations'

The Institution of Chemical Engineers have published a new edition of their 'Regulations for the Admission of Student, Graduate and Corporate Members, and for the Examination of the Institution.' This edition contains some guidance on training and experience requirements, while a leaflet gives the new syllabus for Paper D (engineering drawing) of the Institution's examination. The engineering drawing syllabus has been revised with a view to giving teachers and students more advice on the content of this part of the examination.

Copies can be obtained from the Institution at 16 Belgrave Square, London, S.W.1.

'Dechema' annual meeting

The 1959 annual meeting of 'Dechema' (Deutsche Gesellschaft für Chemisches Apparatewesen) takes place on May 21 and 22 at Frankfurt-am-Main. The proceedings will include the presentation of the 'Dechema' prizes for 1957 and 1958 of the Max-Buchner Research Foundation.

There will also be a series of papers on chemical engineering and chemical technology. Laboratory techniques, works techniques and materials techniques will be discussed, as will also various aspects of research and education.

The programme can be obtained from 'Dechema' at Frankfurt (Main) 7, Postfach, Germany.

Control of nuclear reactors

A second course on the control and instrumentation of reactors will be held at the Harwell Reactor School from July 7 to 17, 1959, inclusive, and will be open to British and overseas students. The fee for the course will be 50 guineas, and application forms, which must be returned by May 7, are available from The Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire.

Polymerisation processes

A residential course of lectures and practical exercises, intended to give an introduction to the basic principles of polymerisation processes, is being run at the National College of Rubber Technology, Holloway Road, London, N.7, from July 6 to 15 inclusive. This is a course for the non-specialist, but participants should have a general knowledge of organic and physical chemistry up to approximately B.SC. general level. Fees for United Kingdom students are 22 guineas and, for overseas students, 30 guineas.

Another 10-day course to be held at the same time is designed to give sales, buying, costing and planning staff a broader knowledge of basic rubber technology.

Rubber and plastics in South Africa

A South African section of the Institution of the Rubber Industry is to be established and will consist of a central council in Johannesburg with branches in Johannesburg, Durban and Port Elizabeth.

Companies and personnel engaged in rubber and plastics manufacture in the Union are invited to apply for membership to the appropriate honorary secretary, *i.e.* Mr. F. C. Moore, Durham Raw Materials, P.O. Box 4142, Johannesburg; Mr. A. J. Robertson, P.O. Box 1515, Durban; or Mr. W. Pickup, P.O. Box 3062, North End, Port Elizabeth.

MEETINGS

Institution of Chemical Engineers

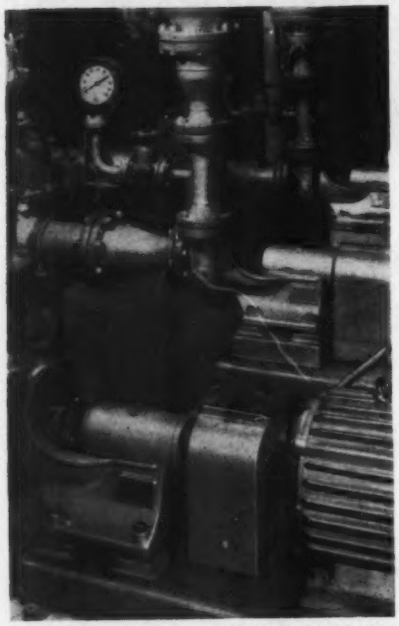
May 11 *to* 13. Joint symposium on 'Instrumentation and Computation in Process Development and Plant Design,' organised jointly with the Society of Instrument Technology and the British Computer Society, Central Hall, Westminster, S.W.1.

Society of Instrument Technology

May 12. 'Temperature Measurement with Resistance Thermometers,' by C. K. Massey, 6.30 p.m., Central Library, St. Peter's Square, Manchester 1.

May 13. 'A Multipoint Digital Strain-gauge Recorder,' by J. R. Sturgeon, 5.30 p.m., Manson House, Portland Place, London, W.1.

Chemical Pumps..?



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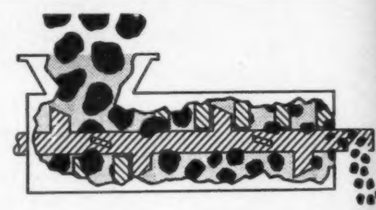

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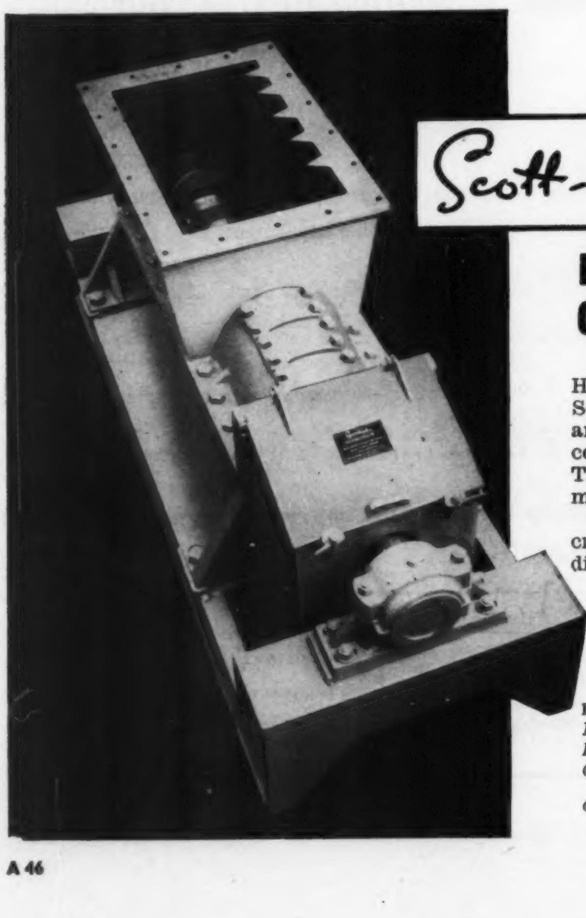

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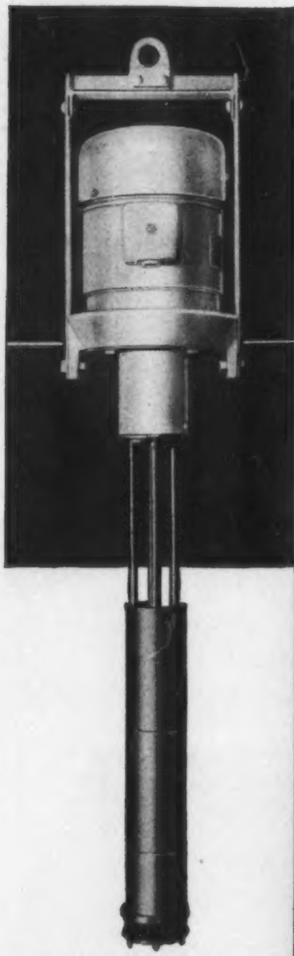

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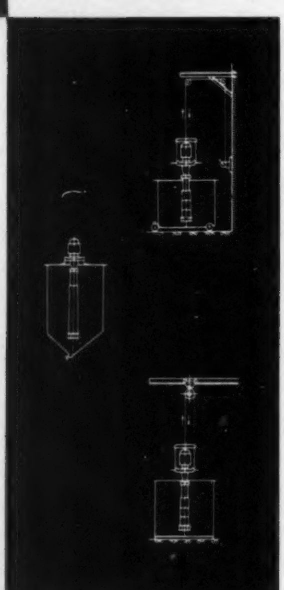

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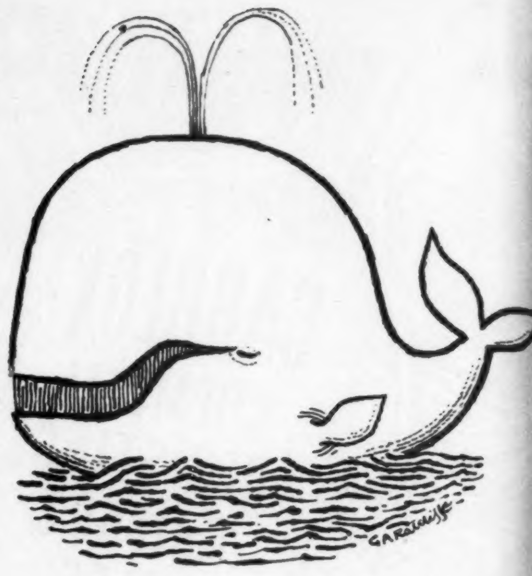

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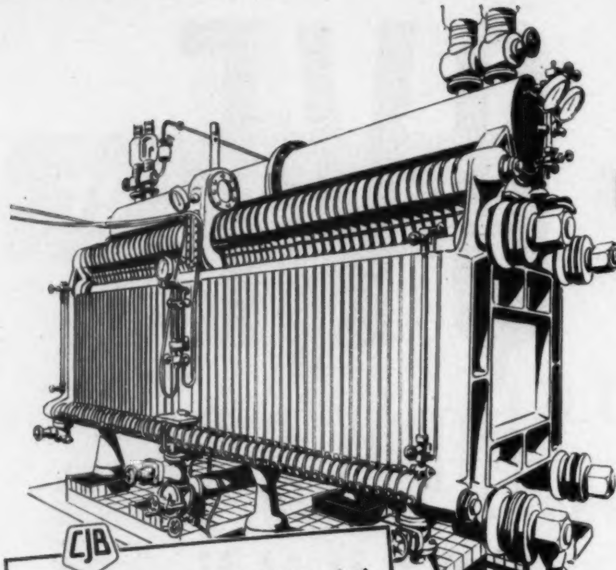

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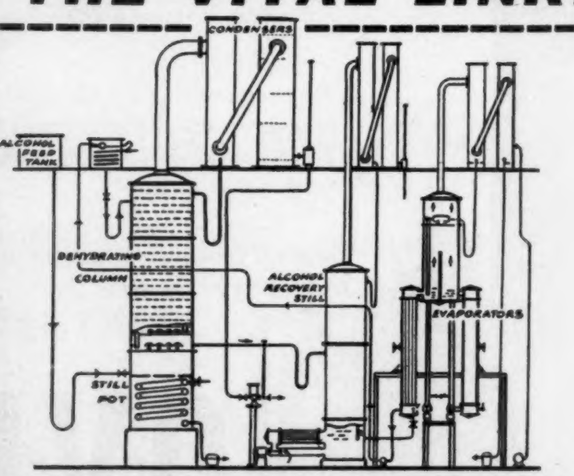

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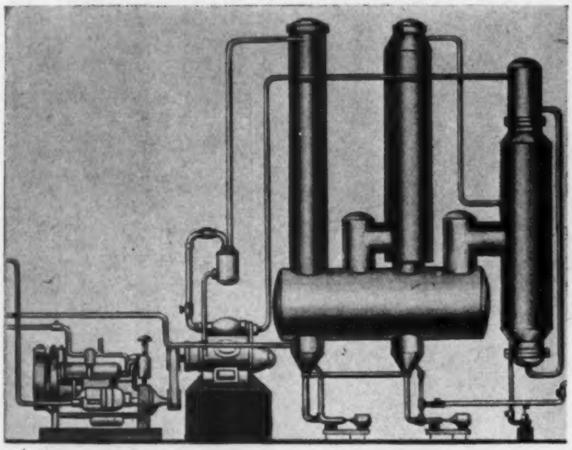

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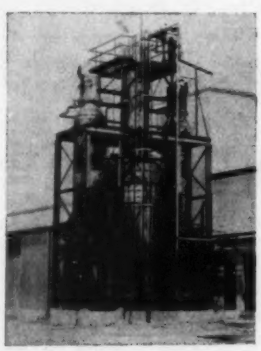

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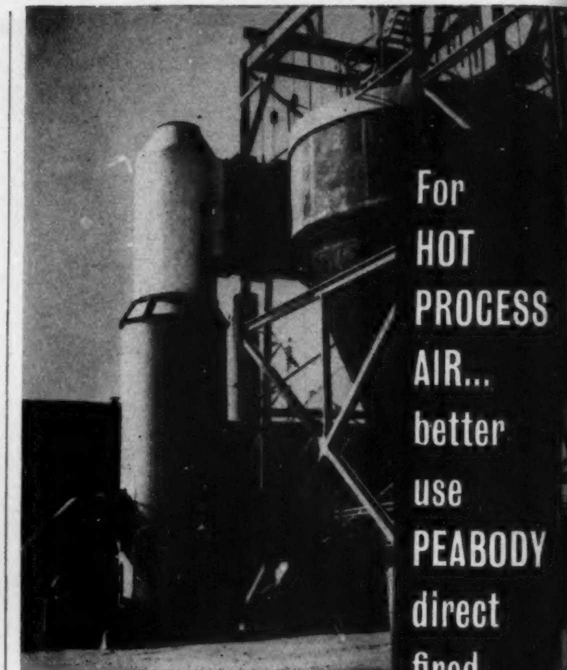

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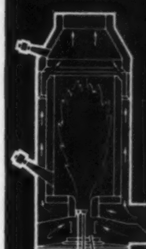

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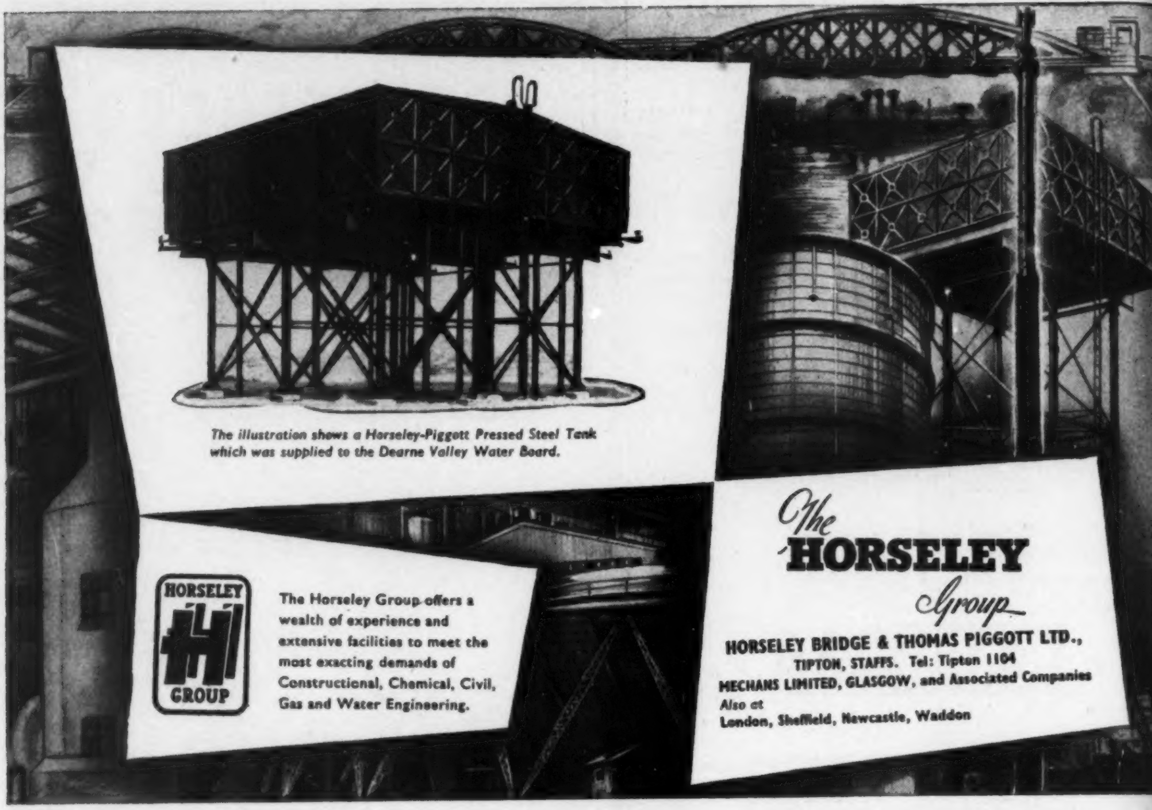

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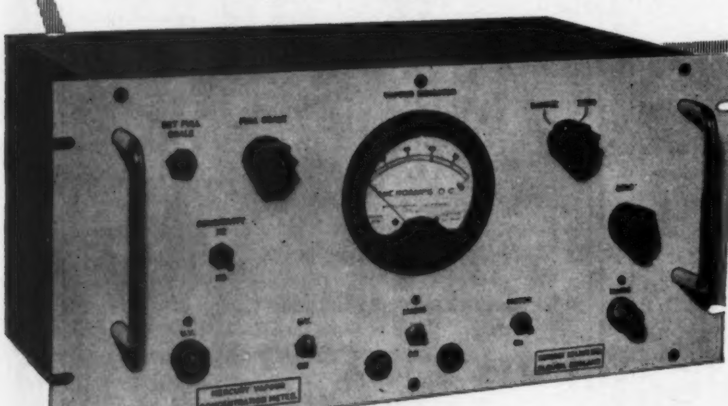

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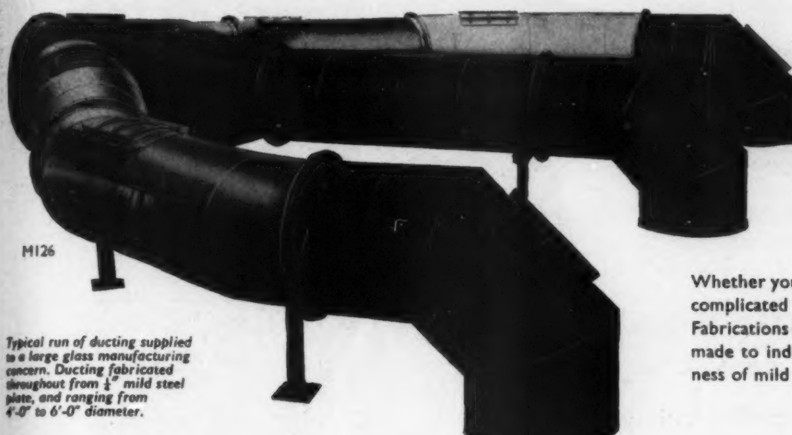

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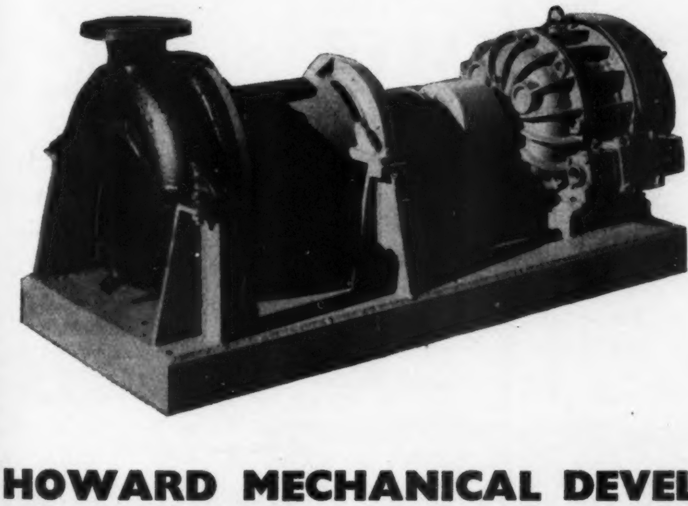

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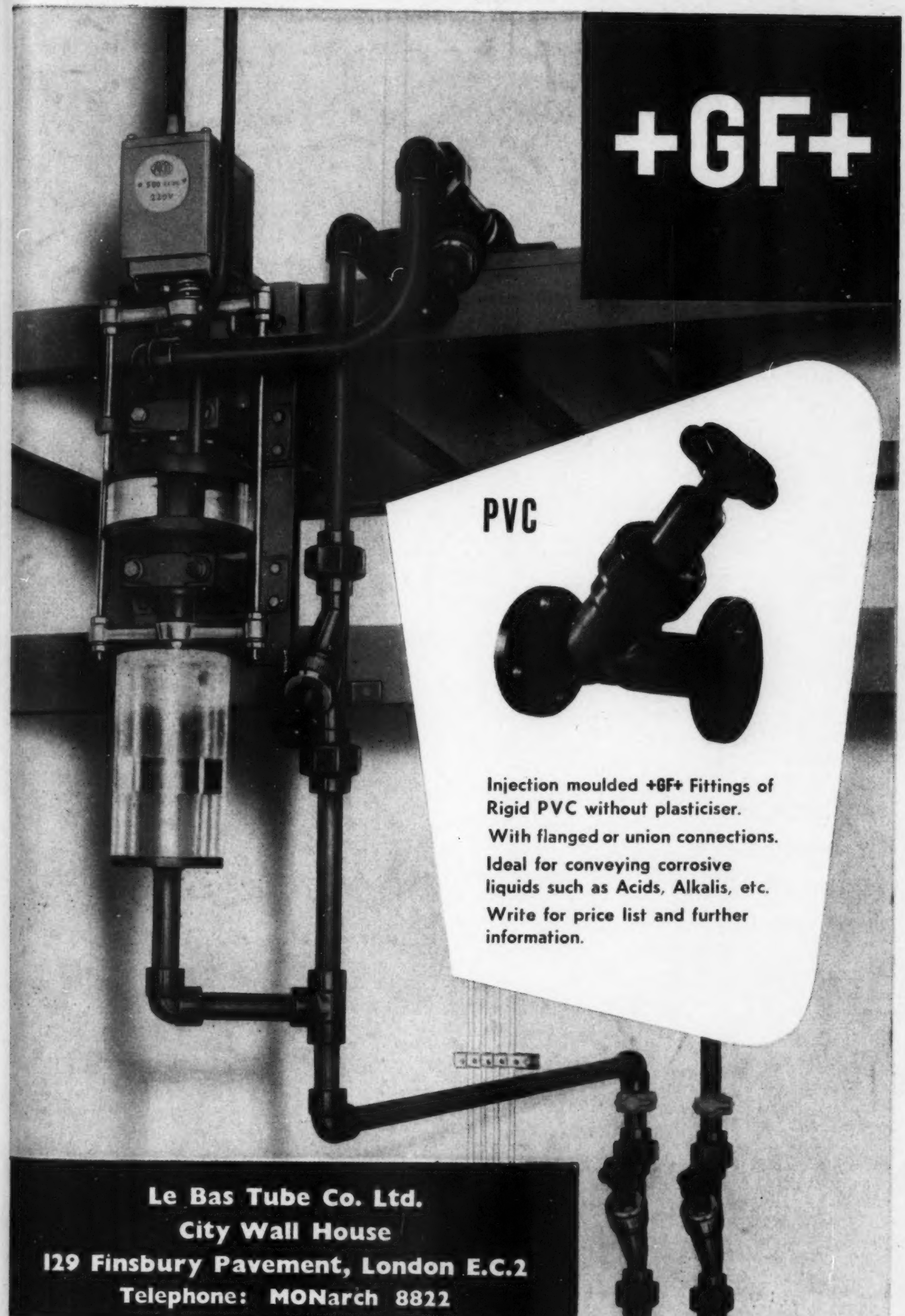

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